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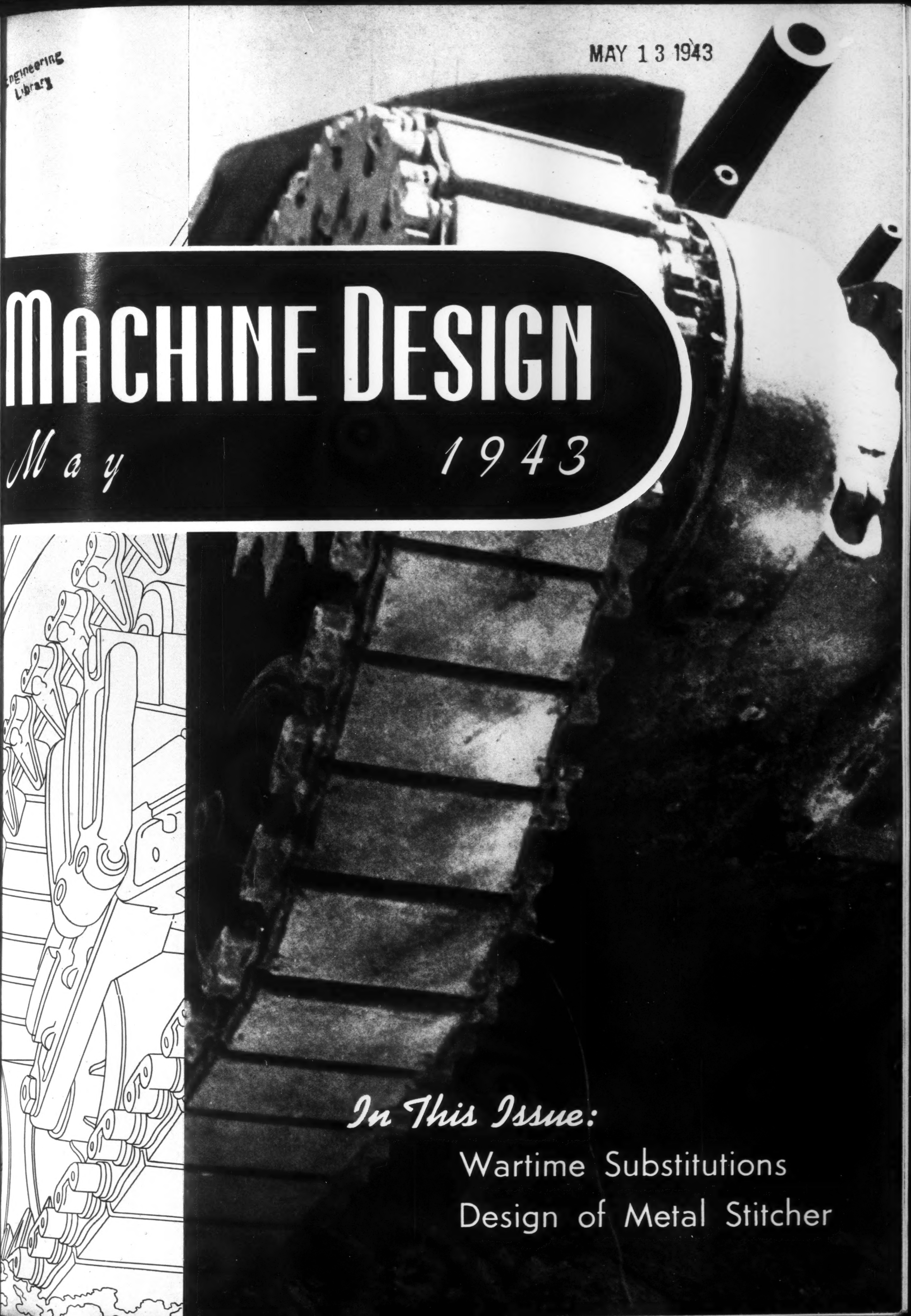
MACHINE DESIGN

May 1943



In This Issue:

Wartime Substitutions

Design of Metal Stitcher

Open Book on WARTIME CARE OF V-Belts

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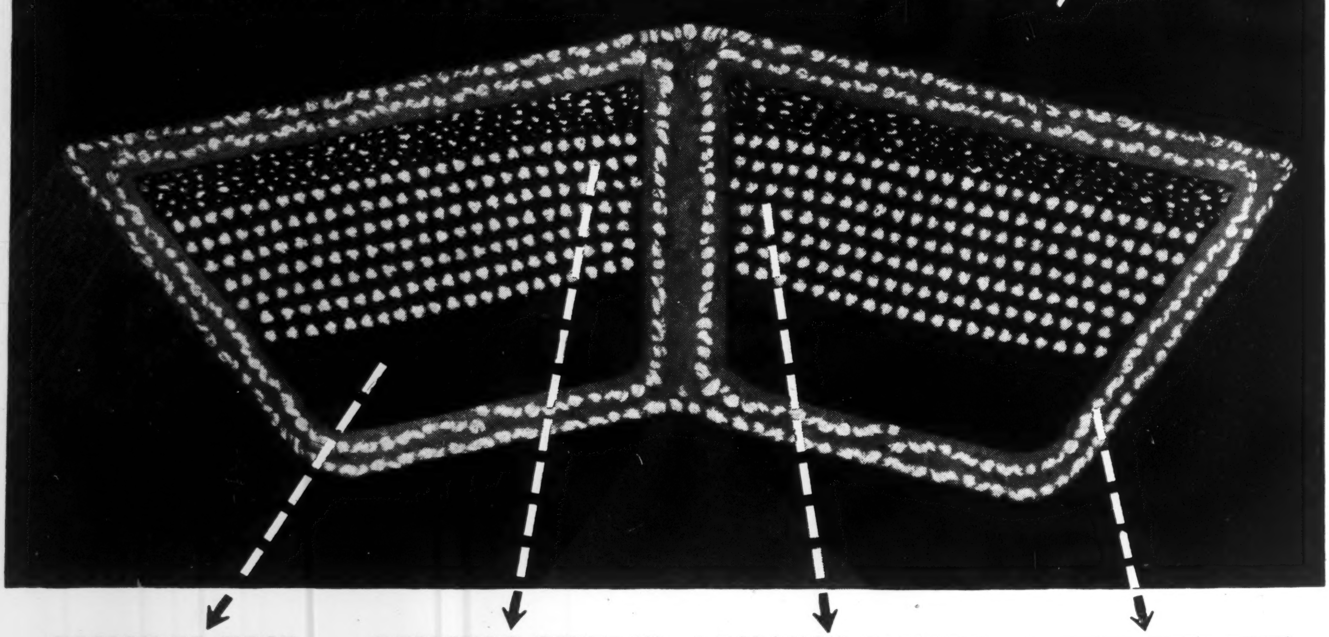

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MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

Volume 15 MAY, 1943 Number 5

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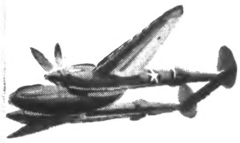

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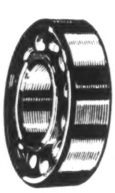

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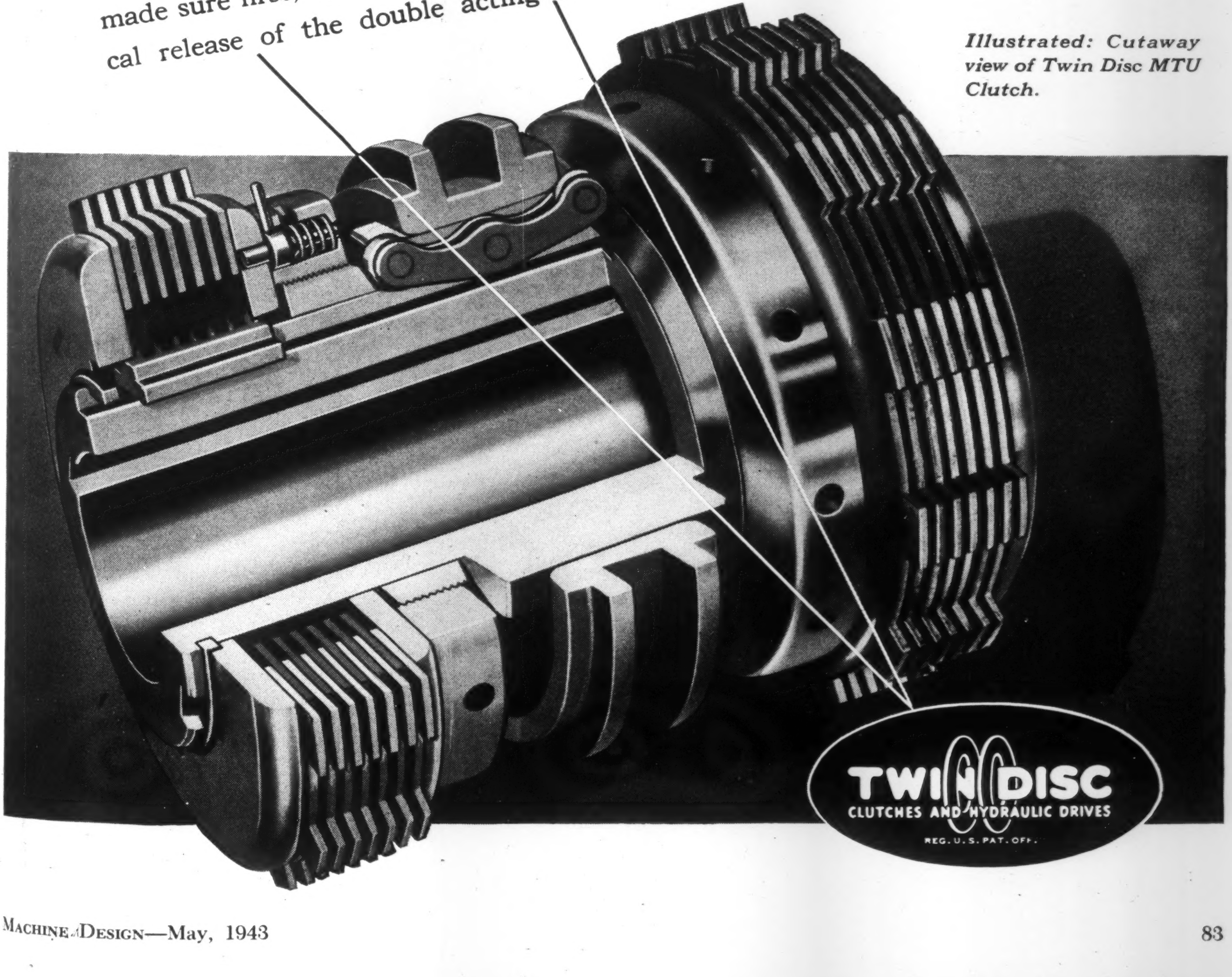
QUICK RELEASE...

Maximum production demands that the machine tool's work cycle be as short as practicable . . . that the clutch not only engage quickly and smoothly but that it release with the same facility. This means that not only must the multiple disc plates separate easily and quickly, but there must be sufficient space between the plates to prevent a time-consuming lag . . . and thus increase the over-all time of the working cycle.

In Twin Disc MTU Clutches this is made sure first, by the positive mechanical release of the double acting clutch levers; second, by providing a shearing action which removes the oil as the clutch is engaged, leaving a minimum to act as an adhesive when the clutch is released; third, through a precision finishing of the best materials for the discs (bronze against steel) sufficient spacing is provided with minimum over-all length.

This is only one feature of Twin Disc Machine Tool Clutches but it shows how closely Twin Disc engineers work with the machine tool builder to assure maximum clutch performance. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin.



Illustrated: Cutaway view of Twin Disc MTU Clutch.

Topics

VIRGIN ALUMINUM saved annually in castings through the substitution of secondary aluminum, by an optical instrument manufacturer, is some 360,000 pounds. Approximately 25,000 pounds was saved on one contract by using zinc instead of aluminum. In another case, by shifting from virgin to secondary copper in bronze, a saving of 440,000 pounds of virgin copper resulted. Another saving of 80,000 pounds virgin copper and 12,000 pounds nickel was effected by substituting copper-weld wire for nickel-silver. By reducing the tin content of bronze from 8 per cent to 4 per cent, an annual saving of 20,000 pounds of tin resulted. Also, 2400 pounds of tungsten is being saved by reducing the percentage of this material in high-speed steels. Elimination of nickel and chrome-plating wherever possible, and substituting silver-plating or lacquering, has resulted in a considerable saving.

REPLACING ICE by a chemical refrigerant in refrigeration and air conditioning not only saves quantities of ice but, more important, gives control of heat and humidity without which much vital war production would be slowed or stopped.

WINDOWS of beryllium in its pure form are more transparent to certain kinds of X-rays than glass and have aided in speeding tests of materials used in various types of war equipment. X-ray absorption of beryllium is less than that of any other material with the exception of cellophane.

NO LESS THAN 300 chief engineers of machinery manufacturing companies and others interested in the electrification of machines attended the recent Machine Tool Forum held in East Pittsburgh. Indicative of the significance of this subject, the number in attendance was more than double that at any previous forum.

SUBMARINE CREWS can now navigate—despite electric power failures caused by explosion of depth bombs—through the aid of luminescent instrument panels which glow in the dark.

TO STIMULATE the use of plain carbon steel and the National Emergency alloy steels, the War Production Board has made arrangements, under which sample quantities of steel for experimental purposes can be delivered to manufacturers or laboratories without regard to preference ratings or authorized controlled material orders. It is necessary to specify that the steel will be used in making tests; that the steel ordered added to the amounts already received or on order from other sources will not total more than 1000 pounds of each composition; and that the total amount on hand does not exceed 3000 pounds.

SIMPLIFICATION PROGRAM of the War Production Board is aimed at eliminating unnecessary items; also at making the best use of our materials and labor by protecting consumers against under-manufacturing and by eliminating over-manufacturing. There not only is an important saving in man-hours and in the use of materials, but the problem of replacement parts is greatly simplified.

INFLATABLE life belt — only slightly larger than a polo belt in collapsible form — is worn by soldiers night and day under necessary conditions and can be instantly transformed into a life preserver by means of an ingenious inflating device. Buoyancy is supplied by two small bullets of compressed liquid carbon dioxide — similar to the cartridges used to charge home syphon bottles in peacetime.

GLASS for use in springs for stresses up to 2000 pounds per square inch is said to be better than steel in many applications as it retains its elasticity over a broader temperature range and is immune to acids, besides being fatigue-resistant.

OVER 6000 workers at Jack & Heintz Co. went through February without a single unauthorized absence, and now the company is challenging all war plants in the country employing 6000 or more workers to match this record. War bonds will be given employees of the winning company.

PLATING can be trebled by use of potassium cyanide in making silver-plated bearings. Formerly imported from Europe, this material is now available in this country. Potassium cyanide is also used in copper-plating war materials and as a nitriding agent in surface-hardening steel.

MACHINE DESIGN

"A STITCH IN TIME"— Modern Version

By R. J. Niederhauser
Project Engineer
Harris-Seybold-Potter Co.

INCREASED production schedules in the aircraft industry early emphasized the need for a fast and positive method of fastening both similar and dissimilar materials. To fill this need the stitchers shown in *Fig.* 1 were designed. These machines, two of three models which have been developed to facilitate the stitching process (*Fig.* 1, insert), are the culmination of fifty-four years experience in stitcher design. Their use during the past six months in one of the country's largest aircraft plants has resulted in time savings of over four hundred man-hours per week per machine.

Listed below are the design requirements which were submitted to Engineering:

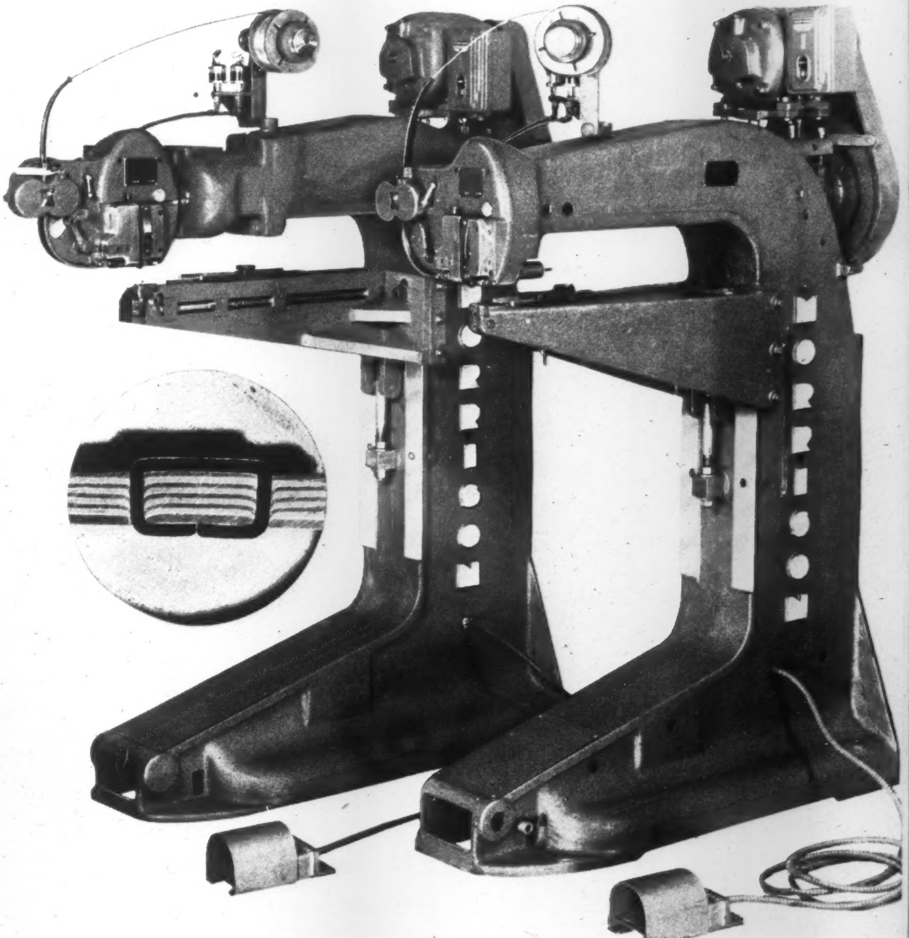


Fig. 1—Right—Aircraft stitchers developed to produce stitch shown in insert. In front is standard arm machine, in back the angle-head model

1. A clean hole, crack-free around the periphery
2. Crown of stitch to be within .002-inch flush with top work surface
3. Legs of stitch to be within .005-inch flush with bottom work surface
4. Maximum production penetration of two sheets of .04-inch 24 ST aluminum alloy
5. Work point to be 25 inches away from columnar support
6. Adjustments to be simple and effortless in order to facilitate operation by unskilled female labor
7. Three models to be developed: Arm machine, *Fig.* 1, front; 90-degree angle head machine, *Fig.* 1, rear; and a post machine.

Design and construction of such a machine would ordinarily call for months of development and several models before a production machine could be put into the field. The pilot models of the aircraft stitcher, however, were delivered four days after completion, having successfully withstood only one hundred and ninety hours of continuous operation. Design changes after the machines were in the field were negligible.

Investigation preparatory to design disclosed the need of rigidity to a higher degree than heretofore found necessary in stitching machines. The extremely high forces required to collapse and flatten the stitch leg made imperative the use of impact and wear-resistant steels in all affected parts. Punch and die alignment which could be maintained to close tolerances over the ¾-inch vertical adjustment range, 25 inches away from columnar support, further indicated the necessity of a one-piece, punch-press section frame with gib and way arm adjustment.

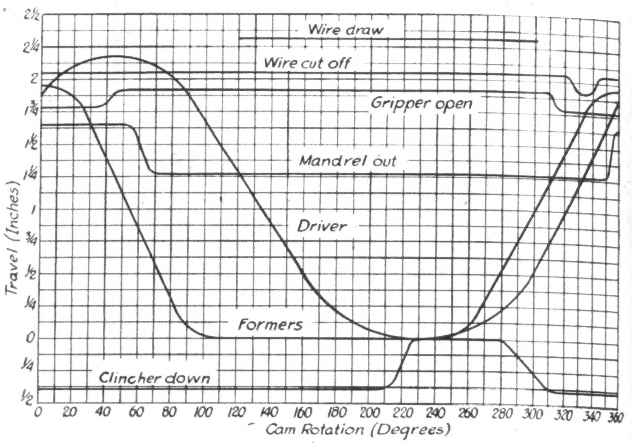
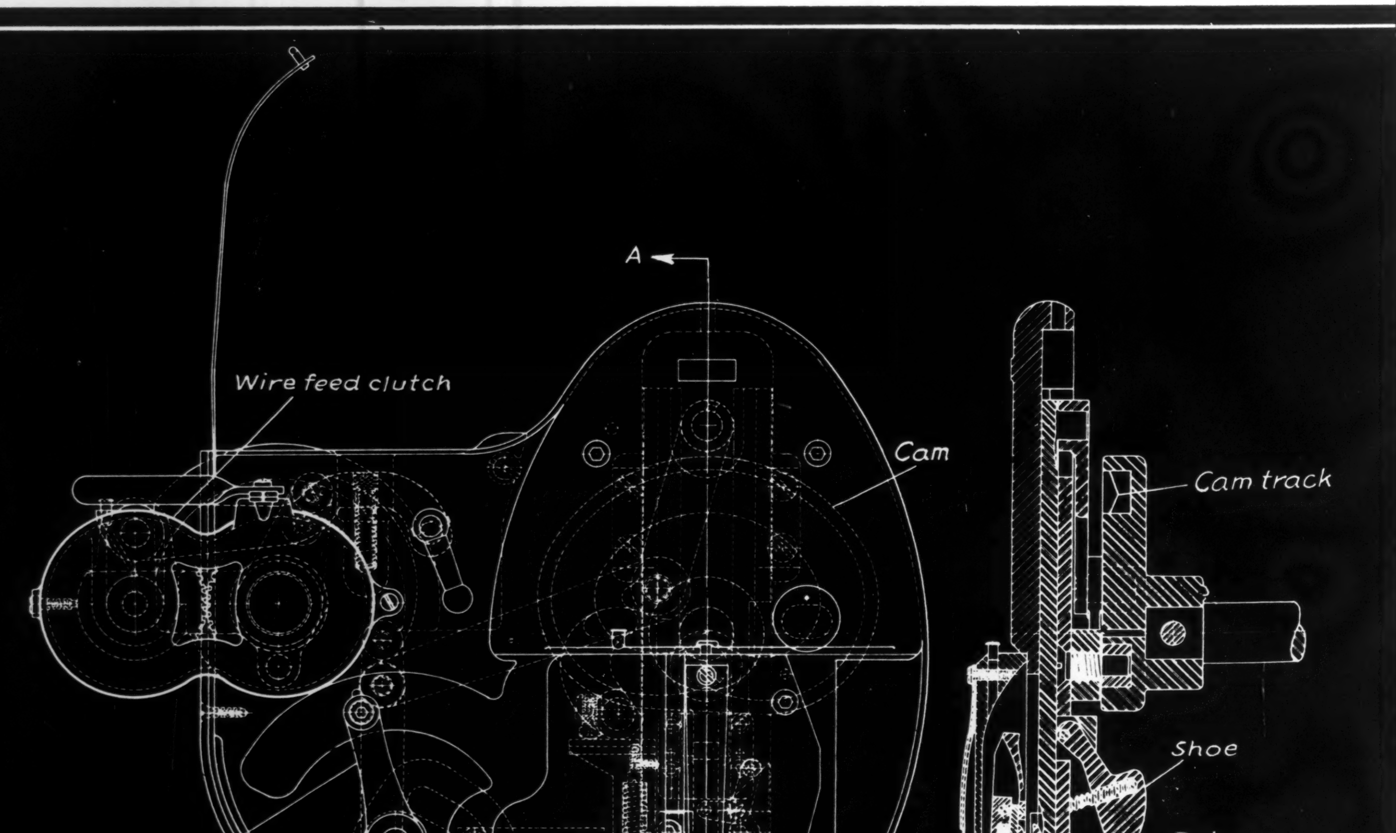


Fig. 3—Timing chart shows relative motions

The machine draws wire from a coil in adjustable lengths of from ⅝-inch to 2⅜ inches (*Fig.* 2). This length of wire is gripped in the mandrel and a knife severs it at the desired length. The mandrel then carries the wire into position under the formers which, in descending, bend the wire into the inverted-U shape which is the stitch and continue to their lower position, clamping the work at the same time to the dies. A pivoting

Fig. 2—Faceplate assembly contains mechanisms for cutting and forming wire and driving it through work



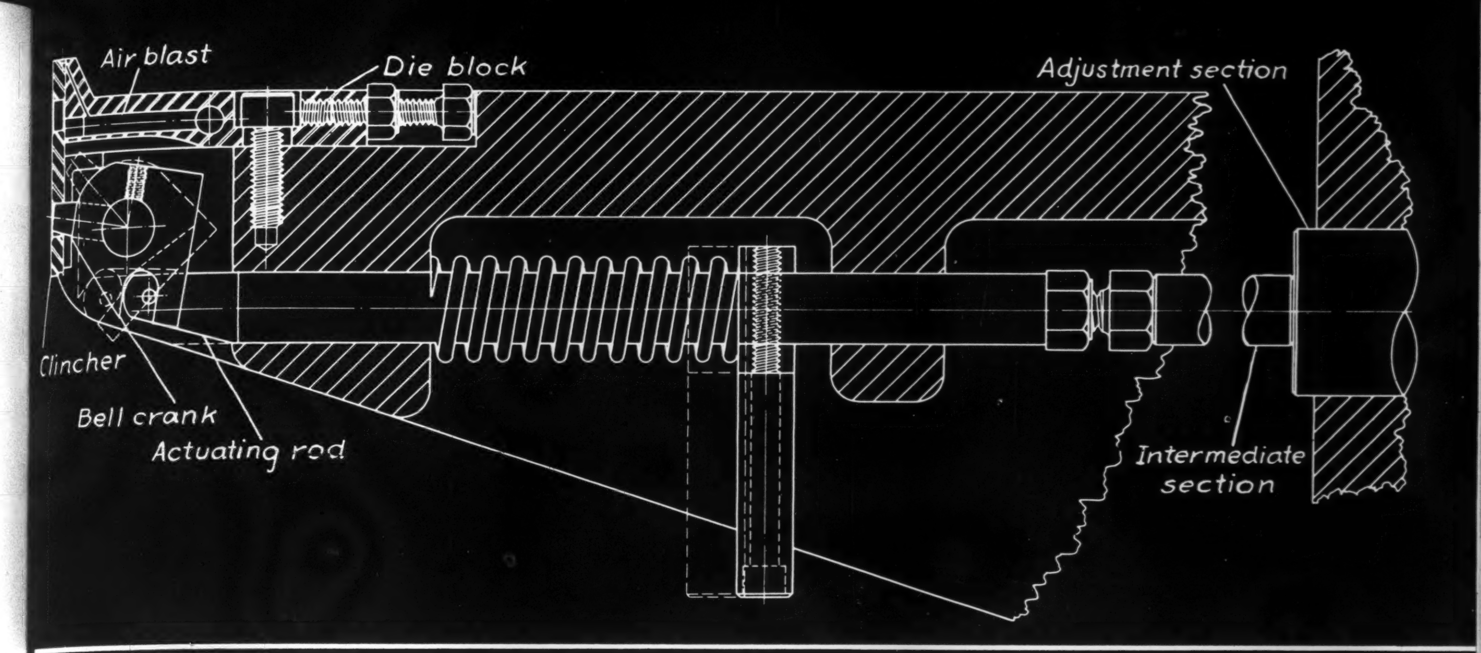
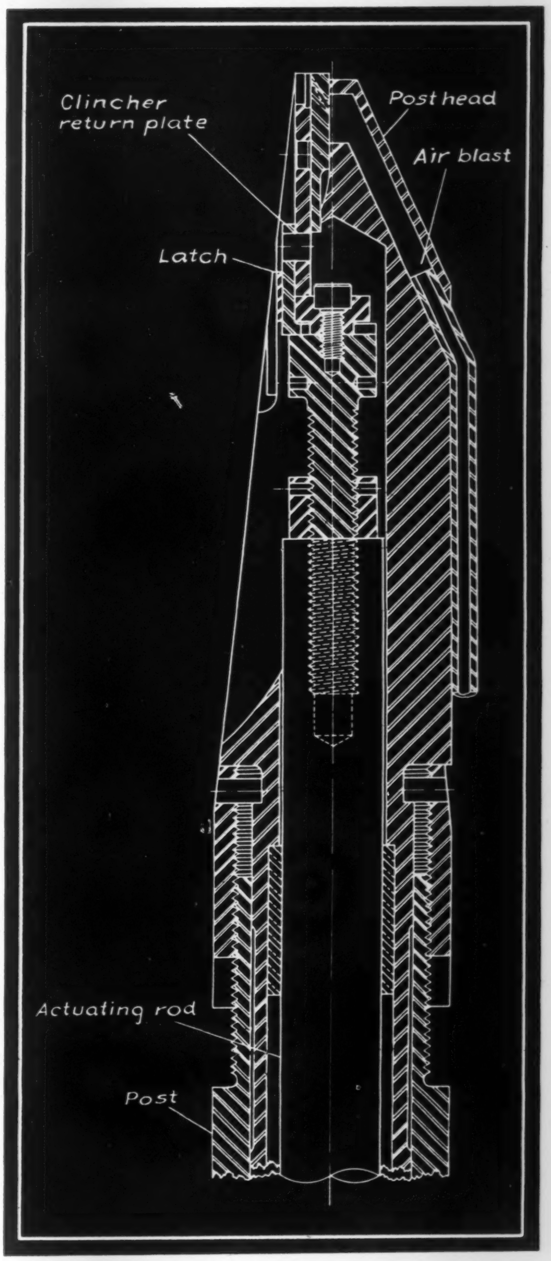


Fig. 4—Section through standard arm shows clincher mechanism with provision for removing the double-ended clincher plate

Fig. 5—Right—Post head clincher mechanism also provides for clincher removal without special tools. Slugs punched from work are blown free by timed air blast



member, the shoe, is cammed forward under heavy spring pressure as the formers descend. The shoe is restrained in its forward movement by the underside of the stitch crown and fits snugly between the formers. Function of the shoe is to support the wire on the three inner tangential surfaces at the moment of, and during, penetration. The wire is thus supported during the entire penetration period by the shoe on the inside, around the balance of the leg peripheries by the formers, and around the balance of the crown periphery by the driver. It can be seen that with ideal machine rigidity the wire is capable of penetrating any thickness of a homogeneous material up to that where the shear strength of the section of material being punched equals the strength of the wire in compression.

Air Blast Removes Slugs

As the wire enters the work, it punches clean round slugs ahead of the legs. The dies present shear edges around the outer half of the wire diameter, the inner half, of necessity due to the clinching operation to follow, being unsupported. The slugs are blown free by a timed air blast, and the cylinder moves upward collapsing the legs and flattening them against the work material. The formers and driver leave the work, a new length of wire is fed and cut off, and the machine is ready to repeat the sequence of operations. Machine speed is three hundred and twenty-five stitches per minute. The actual penetration and clinching is accomplished in approximately 1/30 of a second.

In the faceplate, as may be seen in *Fig.* 2, all motions are taken from a combination track cam and crank. The cam was developed to drive the formers to the lower or work-holding position with sufficient lead in respect to the driver to permit the formation of a stitch capable of penetrating and clinching ¾-inch of material. The relative motions of the formers and driver as well as all other faceplate mechanisms may be seen in *Fig.* 3.

One of the more interesting problems was the wire feed linkage. In order to change the length of wire draw, for instance, from 1 inch to 2 inches, the cutoff must be changed ½-inch. This is necessary in order to have the same amount of wire extending on each side of the mandrel, so that a stitch with equal legs will be formed. This is achieved by a system of three links actuating the over-running roller-ratchet clutch, and a cam which determines the cutoff point, attached to the intermediate link. When a change in wire draw is desired the wire draw control lever is rotated clockwise for additional wire length and counterclockwise to shorten the draw. Thus the cutting block is cammed either away from or toward the mandrel and at the same time the floating center of the intermediate link is moved, resulting in a change in angular movement of the clutch. The two-to-one ratio of angular clutch movement to cutoff point is a function of the cam development.

In order to prevent slippage at the start and overrun at the finish of the wire draw, a roller-ratchet, ring-driven clutch with a friction drag brake is used. Older type wire feed clutches were of the interrupted cycle, dog and ratchet type, where maximum velocity might occur at either the start or finish of the wire draw cycle, depending on the method used in limiting the clutch's angular motion. This type clutch often permitted variations in the length of wire drawn. In conventional stitchers this was not a vital factor. In the aircraft stitcher, however, uniform wire draw is of major importance. Since the roller-ratchet clutch used derives its motion from a crank through a link with a relatively flat arc of travel, the motion imparted to the wire is a modified harmonic motion regardless of the length of wire drawn. In a production run wire length seldom varies more than plus or minus .005-inch.

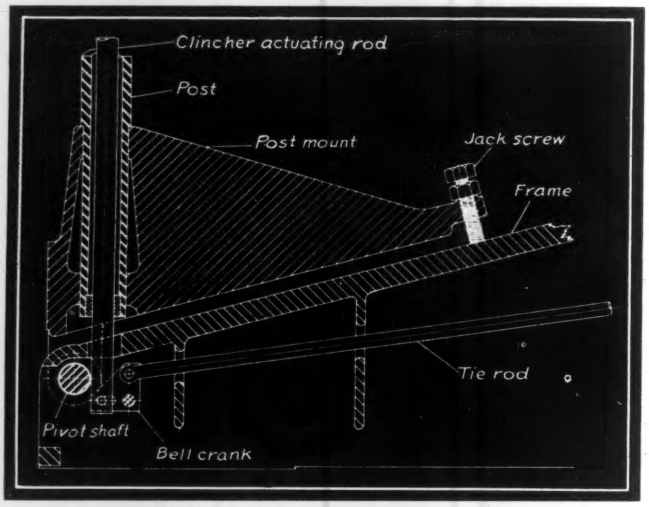


Fig. 6—Mounting for post head maintains accurate die position during clinching but permits post to be tilted forward for loading certain work assemblies

The wire draw occurs during the last half of the cam cycle and since the formers and driver are in the down position it is obvious that the wire must be fed into the mandrel, gripped and cut off in a position in front of its final position under the formers and in line with the forming grooves in the formers.

The mandrel, a forging of SAE 4150 steel, serves two purposes. First it receives the wire as it is drawn and grips it by means of the built-in gripper during cutoff and transfer. Second it supports the crown of the wire during the forming operation. Timing of the mandrel is critical since there is less than 1/30 of a second during which it must move into position under the formers, support the wire while it is formed and return to its normal position. For this reason it was decided to govern the mandrel motion by that of the driver. The mandrel presents a cam surface to the driver which permits spring pressure to move it into position under the formers. After the wire is formed the driver cams the mandrel forward and picks up the formed wire which has remained in the former slots.

Perhaps the greatest design problems were presented by the clinching mechanism. These were problems of space rather than of mechanics. Several methods of applying the clinching force could have been used, the one chosen being selected for its adaptability to a limited amount of space.

Among the designs rejected was one fabricated from steel plate welded into an integral frame consisting of both base and arm. This would have made necessary the incorporation of adjustments in three planes in the clincher box on the working end of the arm. In evaluating the design the advantages were found to be:

1. More rigid structure with smaller sections
2. Adjustments at more convenient working position
3. Elimination of adjustment joint at base of arm with consequent deflection problems.

Offsetting these were the following disadvantages:

1. Bulky working end of arm (8½ square inches in front elevation)
2. Necessity of fabricating three frames for the three required models rather than having frame interchangeability for two models with the third simply an alteration of the same frame casting
3. Necessity for three separate sets of frame tools
4. Use of steel plate and welding rods which were expected to become even more critical materials
5. Necessity of purchasing torch-cutting equipment or subcontracting the frames.

Another arm design rejected was the conventional pivot type which swings in an arc about a bearing center in the frame. The only advantage of this type of mounting is its low cost. Among the disadvantages might be listed:

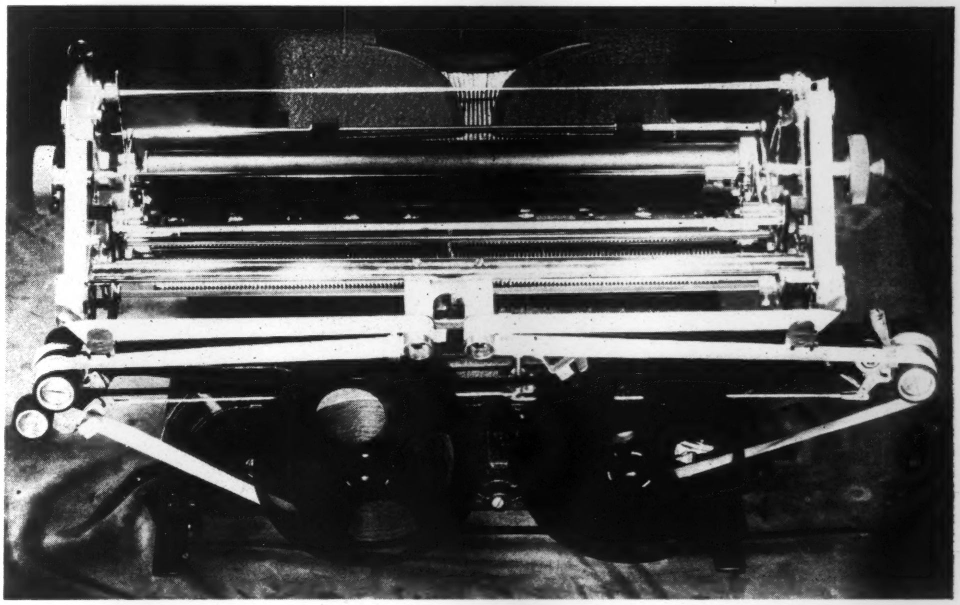
1. Arm swings through an arc for work thickness adjustment. While this is slight it is not a desirable condition
2. Bearing wear at pivot point would make virtually impossible the maintenance of accurate lateral adjustment after several months of production punishment
3. Each change of work thickness would necessitate a clincher adjustment.

Compactness of the assemblies in the final design can be seen in *Figs.* 4 and 5. In the arm machine, *Fig.* 4, the die block provides a mounting for the dies and an outlet for the air blast. It is adjustable fore and aft in a slot milled into the arm. This adjustment is neces-

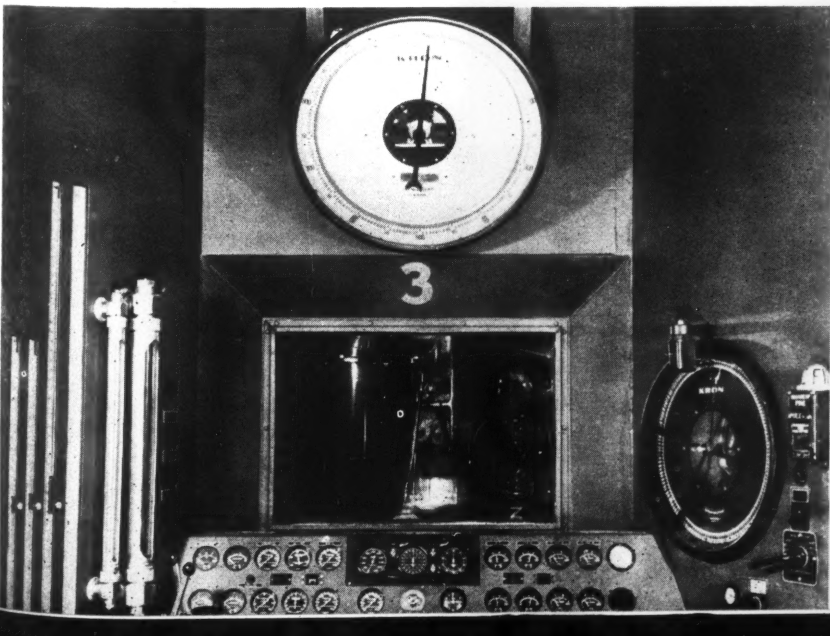
(*Continued on Page* 182)

Scanning the field for IDEAS

AUXILIARY ribbon spools on the IBM typewriter shown right obviates the need for sheets of carbon paper or hectograph paper by providing a ribbon of carbon paper which passes behind the original typed sheet much as the standard ribbon passes in front. Arranged behind the carriage as shown, the additional equipment is designed to be entirely out-of-the-way when not in use, or readily available by lowering a frame which carries the auxiliary ribbon in front of the platen. Reverse or positive copies are produced, depending on the position of the carbon ribbon. Thus, backed original copy may be used for obtaining contact prints.

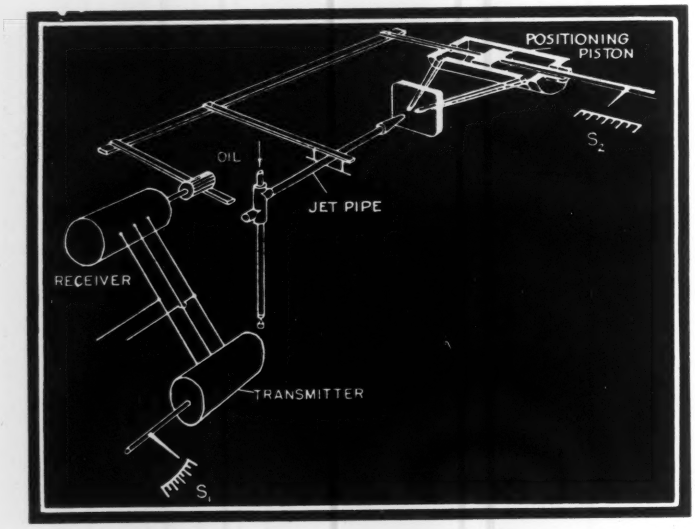


One-man control is now possible for a complete aircraft engine test. Shown below is the control station where a single operator can perform all the operations formerly requiring two or three men. Such a "nerve center" for a test cell provides control of the entire engine-testing sequence. In this test cell, developed by Minneapolis-Honeywell Regulator Co., pneumatic valves, switches and controllers control carburetor air temperature and pressures, gasoline flow and temperature, engine cylinder temperatures singly or in groups, oil flow and temperature, cell ventilation and prestone temperature for liquid-



cooled engines. With these controls it is possible to simulate conditions when flying up to 40,000 feet or in temperatures from the arctics to the tropics. Automatic recording devices take down operational data so that a complete performance record is available. Power developed by the engines on test supplies supplementary power to the manufacturing plant through generators coupled to the test engines.

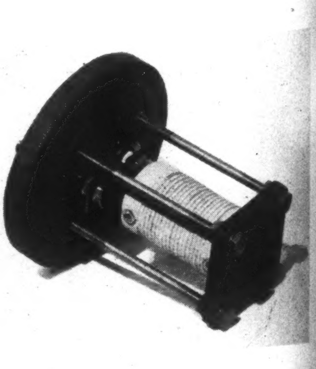
More parts from a single sheet involves careful planning for best possible nesting and often results in changes in manufacturing methods or design. Much thought is given to this phase of materials utilization at the General Electric Co. and, when formulas are not available for intricate shapes, cut and try methods are utilized as shown at right. In one instance this procedure involved changing the number of circle-shaped segments in a set from four to six because the smaller segments had shallower arcs. Resulting saving was 537,000 pounds of steel in one year. Another example involved a stamping job which called for a number of ring shapes and "top hat" shapes. Designs were altered to allow both parts to be stamped from the same thickness of sheet. As a result, in addition to the ring shape, eight top hat pieces were also obtained from a single sheet—one from each of the four corners and four from the center.



Hydraulic relay illustrated schematically at left provides remote control proportional to impulse change. Developed by the Askania Regulator Co., the control combines the advantages of the jet-pipe principle with the unique functions of a selsyn motor. In this way the selsyn movement need merely position the sensitive jet pipe, transmitting an original impulse through a hydraulic system with sufficient power to operate equipment requiring accurate positioning.

As shown in the diagram, a selsyn transmitter positions a receiver which in turn alters the direction of a jet pipe. This movement provides a differential in pressure between the two ends of the positioning piston by directing the jet more or less at each orifice connected to the cylinder ends. The resulting movement will always be proportional to the amount of the original impulse. The factor of power, force or amplification is practically unlimited for this arrangement and extreme accuracies are attainable.

Quick response of protective equipment, warning of faulty operation or potential faults, is necessary for many classes of equipment in remote, unattended locations where dangerous conditions may develop unnoticed within the range of operating personnel. Often such safety devices may be made more responsive to incipient faults through detecting intermediate reactions as is done by the HCl detector developed by Westinghouse for protecting transformers and similar oil-insulated equipment. Normally faults or overloads resulting in arcing are detected by pressure devices such as diaphragms which are actuated or ruptured through decomposition of the oil. Hydrogen chloride, a product of this decomposition, operates the new detector shown at right even before any measurable pressure has been developed, thus giving earlier response than previously possible. The detecting element consists of two bare electrodes wound on an insulated spool and separated by zinc oxide. In the presence of HCl this material becomes zinc chloride and short circuits the electrodes to energize the circuit for warning of equipment failure.



Substitution Challenges Skill of Designer

By A. William Meyer
Assistant Chief Engineer
Brown & Sharpe Mfg. Co.

ANY program of substitution for scarce materials by more abundant or newly developed materials forces the designer to review with a discriminating eye the material requirements for each machine part. No longer can he use the material best suited to the job without regard to the prime source of the material. At the same time, before a substitution is adopted extended consideration and, in many instances, actual tests are necessary. Of prime importance is the maintenance of quality equal to that of the replaced part. Other important factors to be considered include:

1. Continued availability of the substitute material under rapidly changing conditions
2. Suitability of present tooling and equipment to the manufacture of the new material
3. The question of acquiring new facilities to produce the parts made of substitute materials
4. Use of the new parts as repairs for the replaced material
5. Reasonable cost
6. Change of material for a given component part not altering or affecting the operation of the machine. Further changes if necessary to restore the operating conditions.

The foregoing and other points have made the materials substitution problem, if not a spectacular one, at least one of great interest. To illustrate some of the points mentioned, a number of recent changes in machine parts are briefly discussed in the following.

Change-gear guards made of cast aluminum, *Fig.* 1, have for many years past been standard equipment on milling machines. Due to the fact that this particular guard is port-

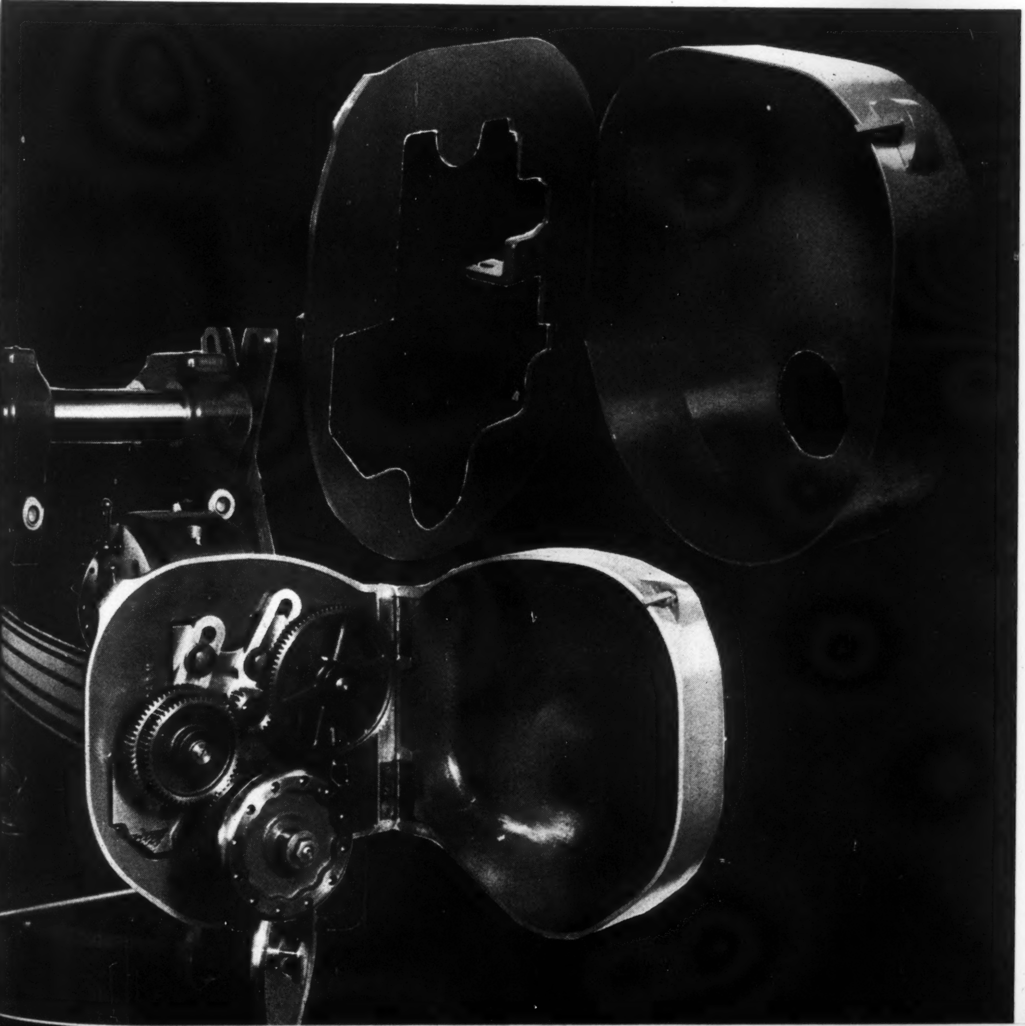
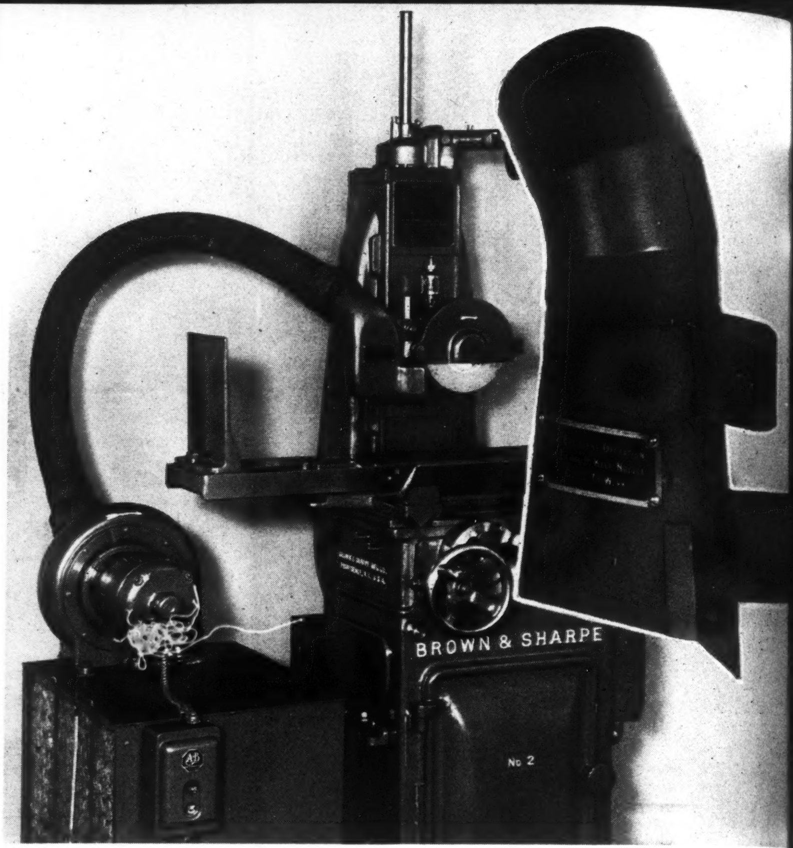


Fig. 1—Light weight was satisfactorily maintained in the substitution of sheet steel for cast aluminum in this change-gear guard on a milling machine

Fig. 2—Right—Sheet steel exhaust nozzle for grinder (inset) weighs less than cast aluminum nozzle which it replaces

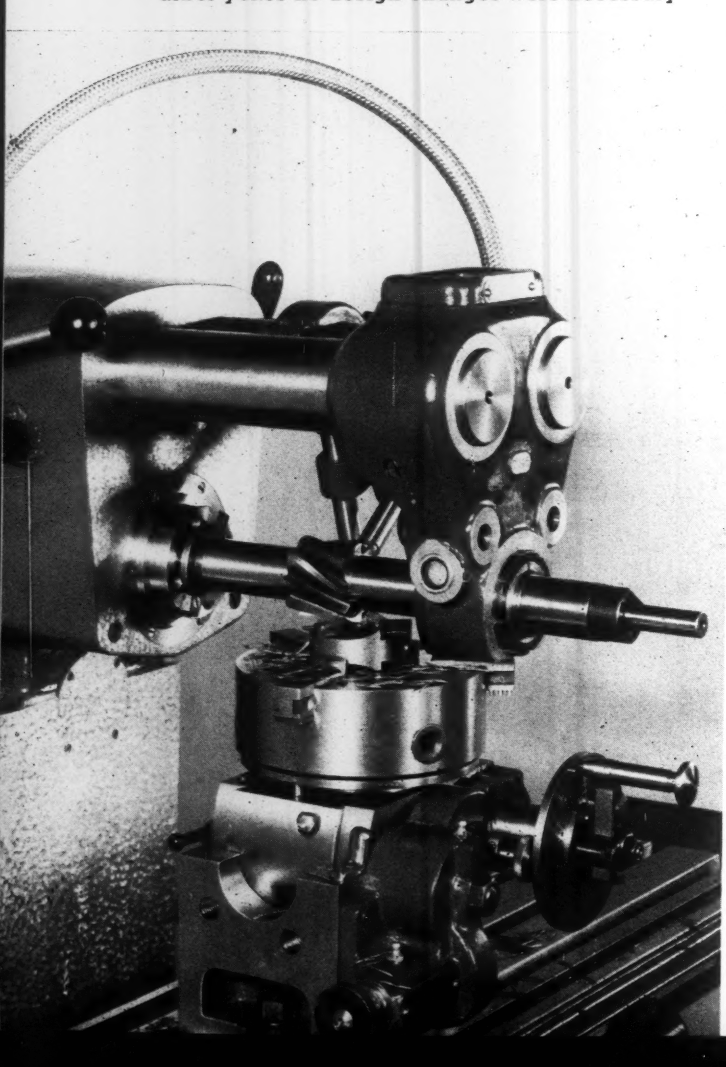


able and because of its location at the extreme end of the table, minimum weight is highly desirable. As a substitute for aluminum in this and similar guards, fabricated sheet steel guards shown in *Fig.* 1, upper right, have been adopted. By the selection of proper gages of sheet material and by developing acceptable shapes to insure rigidity in the assembled form, a satisfactory guard with necessary sturdiness and acceptable lightness has been obtained.

In this instance work has been transferred from machining departments to metal shearing and metal fabricating departments, where there already existed the necessary equipment with sufficient capacity to produce the new guards. This change, furthermore, released machine tools that could be used on other work.

Another instance of substitution of sheet steel for aluminum castings is shown in *Fig.* 2, depicting aluminum exhaust nozzles used on grinding machines. These have been replaced by the fabricated nozzles shown in inset. For this component it is highly desirable to keep weight to the minimum

Fig. 3—Below—In substituting cast iron for aluminum in arbor yokes no design changes were necessary



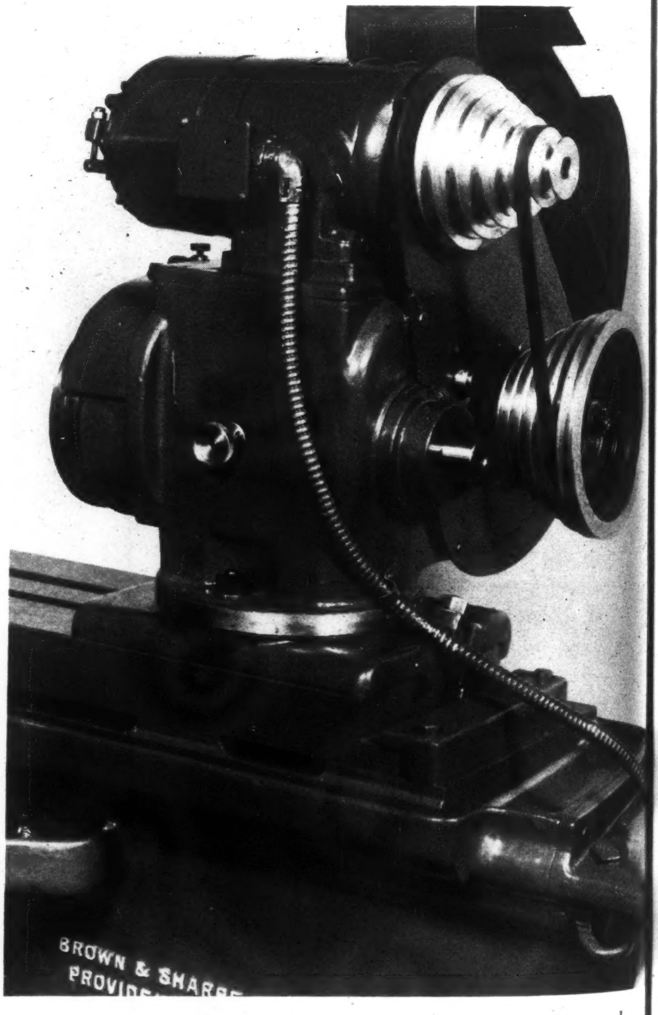


Fig. 4—Replacement of aluminum by cast iron for stepped sheaves introduced problems of inertia due to increased weight of the cast-iron part

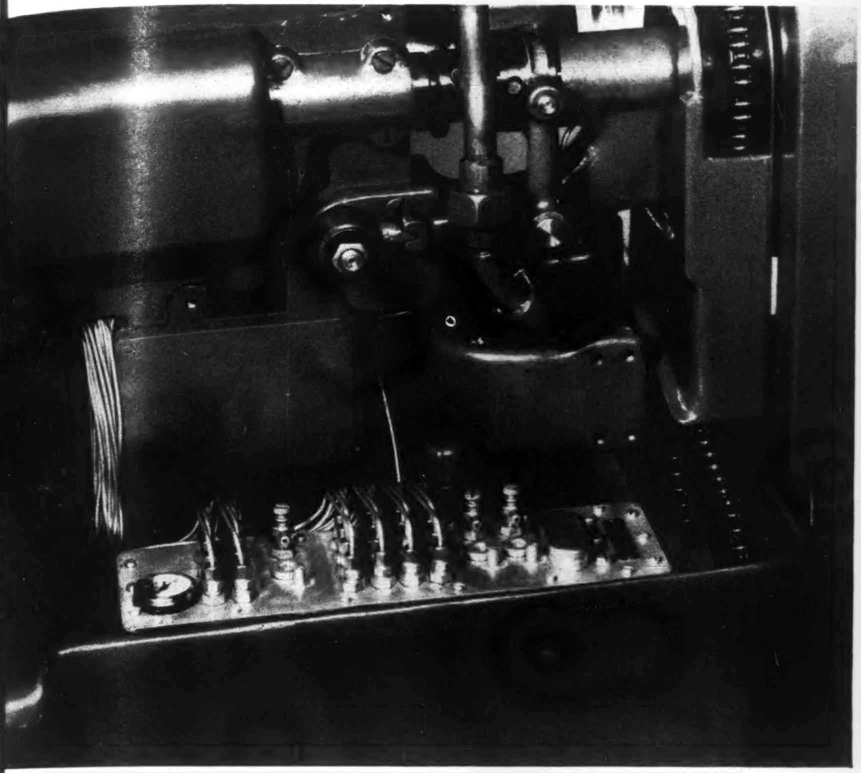
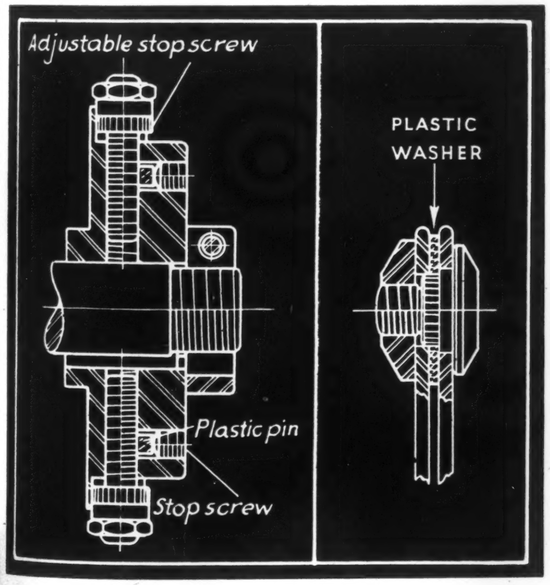


Fig. 5—Thin-walled welded steel tubing for automatic lubrication system is as easily bent to shape as the aluminum tubing which it replaces

Fig. 6—Below—Plastic pins (left) and washers (right) have better frictional properties than the brass parts they replace



and actually the nozzle finally adopted is slightly lighter than the original aluminum nozzle.

Arbor yokes as applied to milling machines, *Fig.* 3, have for some years been made of aluminum. They are now made of cast iron. The only essential change required was to make new pattern equipment to provide for shrinkage and to accommodate different molding practice.

A further saving of aluminum has been made on stepped sheaves used on headstocks of grinding machines as shown in *Fig.* 4. The two sheaves shown have been changed to cast iron. Aluminum was originally adopted for these parts as it was essential that they be light in weight. In the operation of the headstock, quick starting and stopping is important, and when jogging the headstock it is equally desirable to have a quick and positive control of this unit. In adopting cast-iron sheaves, the outward appearance has not been noticeably changed but the coring has been altered slightly to keep the weight at a minimum, and some small ribbing used on the aluminum sheaves has been omitted.

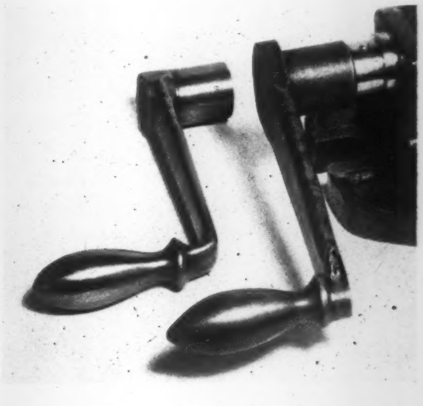
Brake Capacity Increased

These slight changes, although contributing to a reduction in the weight of the sheaves, were not sufficient to produce a satisfactory substitute, as the parts were still somewhat heavy. In order to secure the original operating conditions enumerated above, the capacity of the headstock spindle brake was increased to take care of the inertia factor until operation comparable with that obtained before substitution was secured.

Aluminum tubing for lubrication systems on automatic screw machines was adopted some years ago because copper tubing proved unsatisfactory when used in conjunction with sulphurized oils. As will be seen from *Fig.* 5, the many lines must be bent to different configurations. The requirements for a satisfactory substitute are many: Tubing must be easily bent by hand, and not flatten; it must withstand a temperature of 200 degrees Fahr.; it should be capable of being fastened to the machine at necessary spaced supporting points without sagging; and in view of the fact that some lines are exposed to chips, the tubing should resist cutting and abrasion. After giving consideration to various types of metallic and plastic tubing it was found that electrically-welded steel tubing was as satisfactory as the aluminum previously used. To obtain the same relative ease of bending, the wall thickness of the

(*Continued on Page* 186)

Fig. 7—Right—Welded assembly for crank, extreme right, relieves forging capacity needed for production of crank at right



When Helic

By A. M. Wahl
Westinghouse Research Laboratories

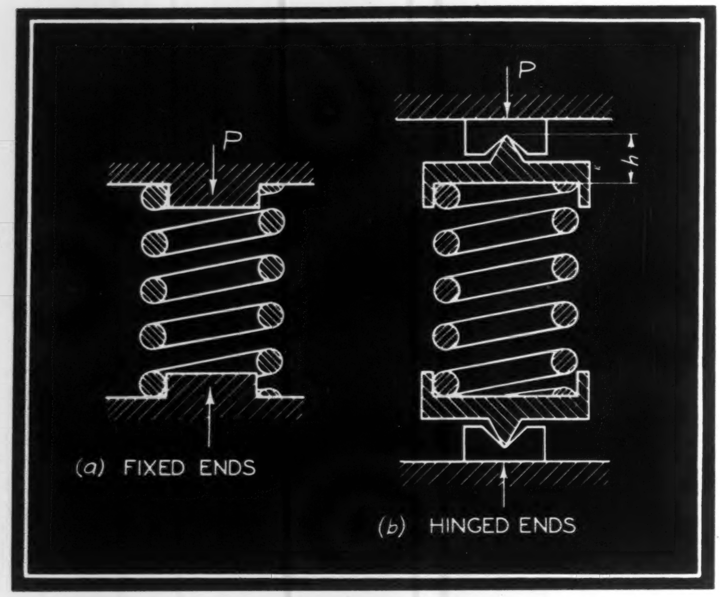


Fig. 1—Critical buckling load of an axially loaded helical spring depends on method of end support

IT IS well known that if a helical compression spring is made too long relative to its diameter, there is danger of sudden sidewise buckling at relatively low loads. However, the fundamentals underlying this instability or buckling action are not so well understood by most engineers. It is the purpose of the present article to explain some of these fundamentals, and to develop formulas which may be used in practical design.

Frequently helical springs are subject not only to a compression load but also to a sidewise or lateral load. This is the case, for example, in certain types of railway truck springs. It will be found that the higher the compression load on the spring, the greater will be the lateral deflection produced by a given lateral force. This problem is thus closely related to that of buckling.

For purposes of analysis a loaded helical spring may be considered essentially as a column under load (1)*. However in making this analysis the increased flexibility of the spring both as regards compression and shear deformation must be taken into account. Thus, for example, the change in length under load of the usual steel column may be neglected, but this cannot be done if a spring is being considered. Also, while shearing deformations are usually negligible for columns, this is not so for helical springs.

Let P_e be the Euler critical load of a column with hinged ends ($P_e = \pi^2EI/l^2$ where EI is the flexural rigidity of the column). This corresponds to the spring loaded as in *Fig. 1b* where the ends may be considered as hinged. If the effect of shearing deformations can be neglected and if the stresses are below the yield point, P_e will also be the buckling load of the column. By taking shearing deformations into account, the formula for the critical load of a column becomes (2):

$$P_{cr}=\frac{P_e}{1+\dfrac{k_1P_e}{AG}} \qquad (1)$$

In this AG/k_1 is the shearing rigidity of the column. This formula indicates that if the shearing rigidity is reduced (assuming a constant Euler load) the buckling load also will be reduced.

To apply this formula to a spring, the load P_e is taken as $\pi^2\beta/l^2$, instead of π^2EI/l^2, where β is the flexural rigidity of the spring in the compressed condition and l is the length of the spring when buckling occurs. The flexural rigidity may be defined as the ratio of bending moment to curvature of the center line of the spring where the latter is subject to pure bending. Instead of AG/k_1 in Equation 1 the shearing rigidity of the spring γ, defined as the ratio of shearing force to shearing deflection per inch of length, is used. With these changes the buckling load for a spring having hinged ends becomes:

$$P_{cr}=\frac{\pi^2\beta}{l^2}\left(\frac{1}{1+\dfrac{\pi^2\beta}{l^2\gamma}}\right) \qquad (2)$$

It will be found that for a spring with a given number of coils the shearing rigidity γ and flexural rigidity β are both directly proportional to the compressed length of the spring. Let l_0 be the free length of spring and β_0, γ_0 the flexural and shearing rigidities for a spring of length l_0. Then $\beta = \beta_0 l/l_0$ and $\gamma = \gamma_0 l/l_0$. Substituting these values in Equation 2,

$$P_{cr}=\frac{\pi^2\beta_0}{ll_0}\left(\frac{1}{1+\dfrac{\pi^2\beta_0}{l^2\gamma_0}}\right) \qquad (3)$$

From the usual spring deflection formula the total compression $(l_0 - l)$ of the spring at the buckling load P_{cr} may be written:

$$l_0-l=\frac{64P_{cr}r^3n}{Gd^4} \qquad (4)$$

where r = mean coil radius, n = number of active turns, d = wire diameter, G = modulus of rigidity.

The compressive rigidity α_0 of a spring of length l_0 is

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*References in parentheses are listed at end of article.

Springs Buckle!

PRESENTING a discussion of the buckling of helical springs together with the related problem of combined lateral and axial loading, this article is based on a chapter of Dr. Wahl's book, to be published shortly, covering design of mechanical springs

defined as the ratio of load to deflection per unit length. Again using the ordinary spring deflection formula,

$$\alpha_o = \frac{Gd^4 l_o}{64 r^3 n} \qquad (5)$$

By substitution of this in Equation 4 the critical load may be expressed as:

$$P_{cr} = \left(1 - \frac{l}{l_o}\right)\alpha_o \qquad (6)$$

Equating the values of P_{cr} given by Equations 3 and 6, and rearranging terms, the following equation is obtained:

$$\left(\frac{l}{l_o}\right)^3 - \left(\frac{l}{l_o}\right)^2 + \frac{\pi^2\beta_o}{l_o^2}\left(\frac{1}{\gamma_o}+\frac{1}{\alpha_o}\right)\frac{l}{l_o} - \frac{\pi^2\beta_o}{l_o^2\gamma_o} = 0 \qquad (7)$$

Since the values of α_0, β_0 and γ_0 may be calculated from the spring dimensions, by solving this equation for l/l_0 the critical length l at which buckling occurs may be found.

To calculate the flexural rigidity β_0 of the spring, it is necessary to calculate the angular deflection of the ends of a helical spring subject to a pure bending moment as shown in *Fig.* 2. Assuming the spring is close-coiled, the latter may be considered as made up of a number of quarter-coils acted on by moments M as indicated in *Fig.* 3, the moment being here represented by the vector. The total deformation will then be the sum of the individual deformations of each coil.

Considering the quarter-coil of *Fig.* 3, at any cross-section at an angle ϕ, the bending moment M_b will be $M \cos \phi$ while the twisting moment M_t will be $M \sin \phi$. The component of angular twist about the spring axis $y - y$ due to the twist of a short length $ds = rd\phi$ will be:

$$d\theta = \frac{M_b ds \cos\phi}{EI} + \frac{M_t ds \sin\phi}{GI_p} \qquad (8)$$

In this I and I_p are the moments of inertia of the bar section in bending and torsion respectively. Substituting $M_b = M \cos \phi$, $M_t = M \sin \phi$ and $ds = rd\phi$ in Equation 9, the following equation is obtained:

$$d\theta = \frac{Mr}{EI}\cos^2\phi \, d\phi + \frac{Mr}{GI_p}\sin^2\phi \, d\phi \qquad (9)$$

The total angular twist θ for a complete turn of the spring will be four times the integral of this between $\phi = 0$ and $\phi = \pi/2$. By integration, the angle θ becomes:

$$\theta = \frac{\pi Mr}{EI}\left(1+\frac{EI}{GI_p}\right) \qquad (10)$$

If the free length is l_0, the number of turns per inch axial length will be n/l_0. This means that the angular deflection in one inch axial length will be $n\theta/l_0$ which will also be equal to the curvature $1/\rho$ of the center line of the spring. Hence, taking $I_p = 2I$ for a circular cross section of the spring bar and using Equation 10,

$$\frac{1}{\rho} = \frac{n\theta}{l_o} = \frac{n\pi Mr}{l_o EI}\left(1+\frac{E}{2G}\right)$$

From this the flexural rigidity β_0, which is the ratio of bending moment M to curvature $1/\rho$, is obtained:

$$\beta_o = \frac{2 l_o EIG}{n\pi r(2G+E)} \qquad (11)$$

To calculate the shearing rigidity γ_0 the deformation of a single ring subject to a shear force Q is considered (*Fig. 4a*). To calculate the deformation of this ring consider the deformation of the quarter-turn subject to the force Q

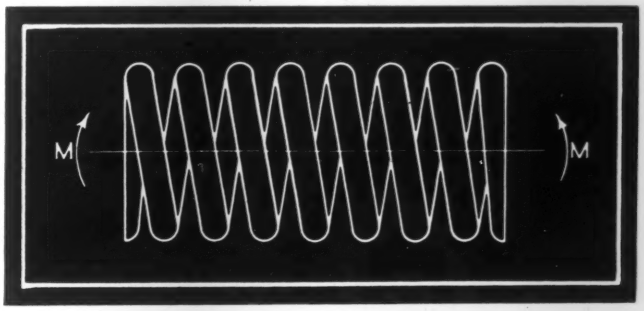


Fig. 2 — Above — Resistance of spring to bending moment in plane of axis is a factor in determining buckling load

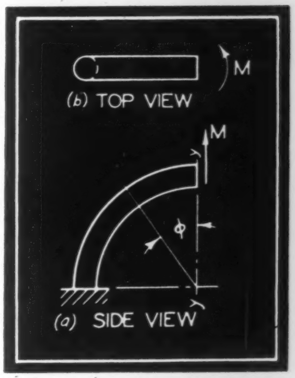


Fig. 3—Right—Consideration of quarter-coil leads to equation for bending rigidity of complete spring

as shown in *Fig. 4b*. From known curved bar theory (3) this deflection is given by:

$$\delta = \frac{\pi}{4} \frac{Qr^3}{EI} \qquad (12)$$

To get the deflection y for a complete turn under a shear force Q (*Fig. 4a*) this value is multiplied by 4. Thus the shear deflection per turn becomes:

$$y = \frac{\pi Qr^3}{EI} \qquad (13)$$

Since there will be n/l_0 turns of the spring per inch axial length, the total shearing deflection per inch is:

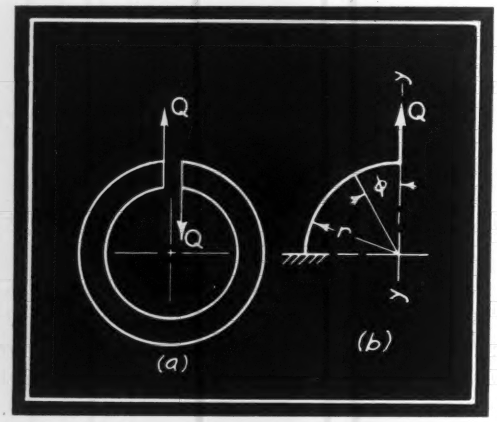
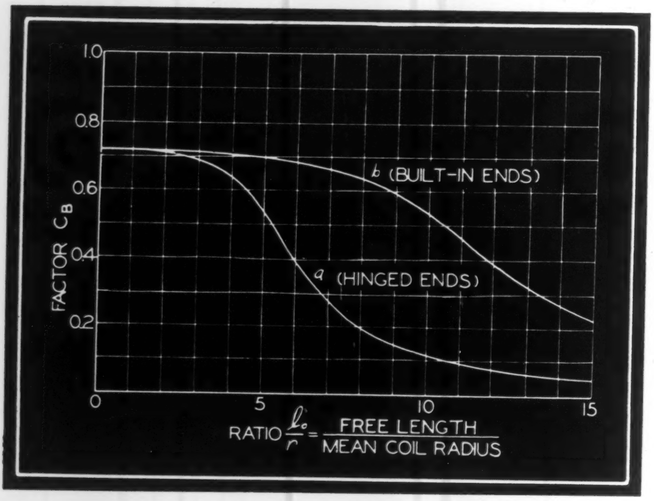


Fig. 4—Above—Deformation of single coil (a) is calculated from analysis of quarter-coil depicted in diagram (b)

Fig. 5—Below—Curves show column effect or buckling load factor for springs of various slenderness ratios



$$\frac{n}{l_o} y = \frac{\pi n}{l_o} \frac{Qr^3}{EI}$$

Using this the shearing rigidity γ_0 thus reduces to:

$$\gamma_o = \frac{l_o EI}{\pi n r^3} \qquad (14)$$

Substituting Equations 5, 11 and 14 for α_0, β_0, γ_0 in Equation 7 and taking $G = E/2(1-\nu)$ where ν = Poisson's ratio:

$$\left(\frac{l}{l_o}\right)^3 - \left(\frac{l}{l_o}\right)^2 + (3+2\nu) m \frac{l}{l_o} - m = 0 \qquad (15)$$

where

$$m = \frac{\pi^2 r^2}{l_o^2 (2+\nu)} \qquad (16)$$

It will be found that Equation 15 has one real positive root which determines the critical value of l/l_0 at which buckling occurs. Using this value in Equation 6 the critical buckling load P_{cr} may be found. The final result may be expressed by the simple formula:

$$P_{cr} = C_B l_o C_k \qquad (17)$$

where C_k = spring constant of spring = load per inch of deflection and C_B = a factor depending on the ratio l_0/r between free length and mean coil radius. For a spring with hinged ends, as was assumed in the derivation, the factor C_B is given by the lower curve *a* in *Fig. 5*. A spring loaded between two pivots as indicated in *Fig. 1b* might be considered approximately as a spring with hinged ends provided that the distance h is small compared to the compressed length.

Where the ends of the spring may be considered as fixed (this condition holds approximately when the spring is compressed between parallel plates as shown in *Fig. 1a*) a similar analysis may be carried out. For test results and further discussion see reference (4). The results may be written in the same form as Equation 17 except that the buckling load factor C_B is now to be taken from the upper curve *b* of *Fig. 5*.

On the basis of available test data, the results as given by Equation 17 may be considered sufficiently accurate for most practical purposes except where the number of coils is too small or when the coils touch before buckling occurs. Some inaccuracy may, however, be expected due to variations in spring dimensions and to the effect of the end turns.

Example 1: As an example of the practical use of these formulas, calculation of buckling load will be performed for a compression spring of the following dimensions: free length l_0 = 6 inches, coil radius r = ¾-inch, wire diameter ¼-inch, active turns n = 12. From calculations, spring tables or charts the spring constant C_k of this spring is found equal to 142 pounds per inch. Assuming that the spring is compressed between parallel plates (*Fig. 1a*) the condition of built-in ends may be assumed; thus the curve *b* of *Fig. 5* is used. From this curve for l_0/r = 6/.75 = 8 the factor C_B = .64. Then from Equation 17 the buckling load is: $P_{cr} = C_B l_0 C_k = .64(6)(142)$ = 545 pounds.

Deflection under combined lateral and axial loading is represented by *Fig. 6* where the spring is loaded simultaneously by an axial load P and a lateral load Q. In the usual case where the spring is compressed between parallel plates, there will also be a moment M acting at the ends as shown. This case may also be considered essentially as a column subject to a lateral load, one end being fixed and the other free to move but restrained from rotation (5). The procedure in calculating such a column is as follows: First the lateral deflection δ_0 is calculated as though there were no axial load. Next the critical buckling load P_{cr} is found from Equation 17 for the case of built-in ends using curve *b* of *Fig.* 5. If P is the axial load, the ratio P/P_{cr} is thus found. As was shown in a previous article (5), because of the presence of the axial load the lateral deflection is increased by a factor C_1 where:

$$C_1=\frac{1}{1-\dfrac{P}{P_{cr}}} \qquad (18)$$

Thus the actual lateral deflection becomes:

$$\delta=C_1\delta_0 \qquad (19)$$

To calculate the lateral deflection δ_0 which would occur if no axial load were acting, the results of beam theory may be used. The spring of *Fig.* 6 loaded by a lateral load Q may be considered essentially as two cantilevers each of length $l/2$. Using the results of beam theory and replacing the flexural rigidity EI of the beam by the flexural rigidity β of the spring (Equation 11) the lateral deflection becomes:

$$\delta_1=\frac{Ql^3}{12\beta} \qquad (20)$$

In calculating β the compressed length l must be taken instead of l_0 in Equation 11.

To the deflection δ_1 an additional shear deflection δ_s must be added. This deflection is equal to the load Q divided by the shearing rigidity γ and multiplied by the length l. To find γ Equation 14 is used, taking l instead of l_0. Thus the shear component of the deflection reduces to:

$$\delta_s=\frac{Ql}{\gamma} \qquad (21)$$

The total deflection δ_0 is the sum of δ_1 and δ_s. Thus using Equations 20 and 21:

$$\delta_0=\frac{Ql^3}{12\beta}+\frac{Ql}{\gamma} \qquad (22)$$

For the usual steel springs $E = 30 \times 10^6$ pounds per square inch and $G = 11.5 \times 10^6$ pounds per square inch. Using these values and the values of β and γ given by Equations 11 and 14 in Equation 22 the following simplified formula for δ_0 is obtained:

$$\delta_0=\frac{2\,Qnr}{10^6 d^4}(.204l^2+1.06r^2) \qquad (23)$$

This particular formula holds only if steel springs are used

To get the actual lateral deflection, as mentioned previously, the value δ_0 must be multiplied by the factor C_1 of Equation 18.

Example 2: As a practical illustration of the application of these formulas, calculations will be performed for a steel spring subjected to an axial load of 2400 pounds combined with a lateral load of 200 pounds. Dimensions are as follows: Outside diameter = 5 inches, mean coil radius r = 2⅛ inches, bar diameter d = ¾-inch, free length l_0 = 9½ inches, active coils n = 8. From spring charts or tables the spring constant C_k is found to be 732 pounds per inch. For a ratio $l_0/r = 9.5/2.12 = 4.48$, using the upper curve of *Fig.* 5, a value of C_B equal to .7 is obtained. Using these values in Equation 17 gives $P_{cr} = C_B l_0 C_k$ = 4860 pounds. For an axial load P of 2400 pounds, P/P_{cr} = .494 and from Equation 18 the factor C_1 = 1.98.

To calculate the deflection δ_0 without axial load for a steel spring Equation 23 may be used, taking l in this case equal to the free length l_0 minus the deflection due to a load of 2400 pounds. This latter will be $2400/C_k = 2400/732 = 3.28$ inches. This gives $l = 9.5 - 3.28 = 6.22$ inches. For a lateral load Q = 200 pounds, by substitution in Equation 23 the deflection δ_0 becomes .274-inch.

From Equation 19 the deflection at a lateral load of 200 pounds (for C_1 = 1.98) is: $\delta = C_1\delta_0 = 1.98 \times .274$ = .543-inch.

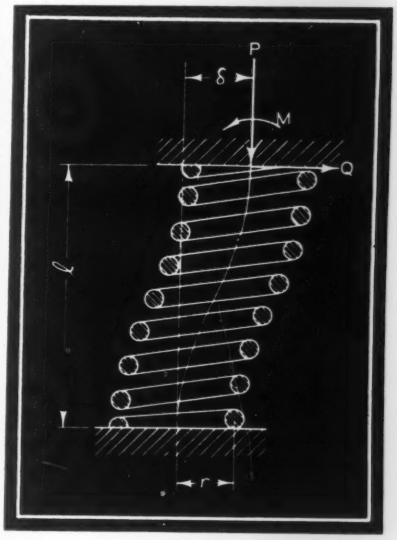


Fig. 6 — Combined lateral and axial loading introduces bending moment due to lateral deflection

Thus it is seen that in this case the actual deflection is about twice that calculated by neglecting the effect of the axial load.

Results obtained by this general method of calculation have been compared with test results (6) and in most cases values obtained agree within about 20 per cent. In a few cases, however, larger discrepancies have been observed. It is of interest to note that by taking special precautions in clamping the ends of the spring and in determining accurately the spring dimensions and effective number of coils, much better agreement between test and theory is possible (7).

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1. S. Timoshenko—*Theory of Elastic Stability*, McGraw-Hill Book Co., 1936. See also articles in *Zeit. fur Angew. Math. und Mechanik*, 1924, Page 384, by R. Grammel and 1925, Page 279, by Biezeno and Koch.
2. S. Timoshenko—*Theory of Elastic Stability*, Page 140.
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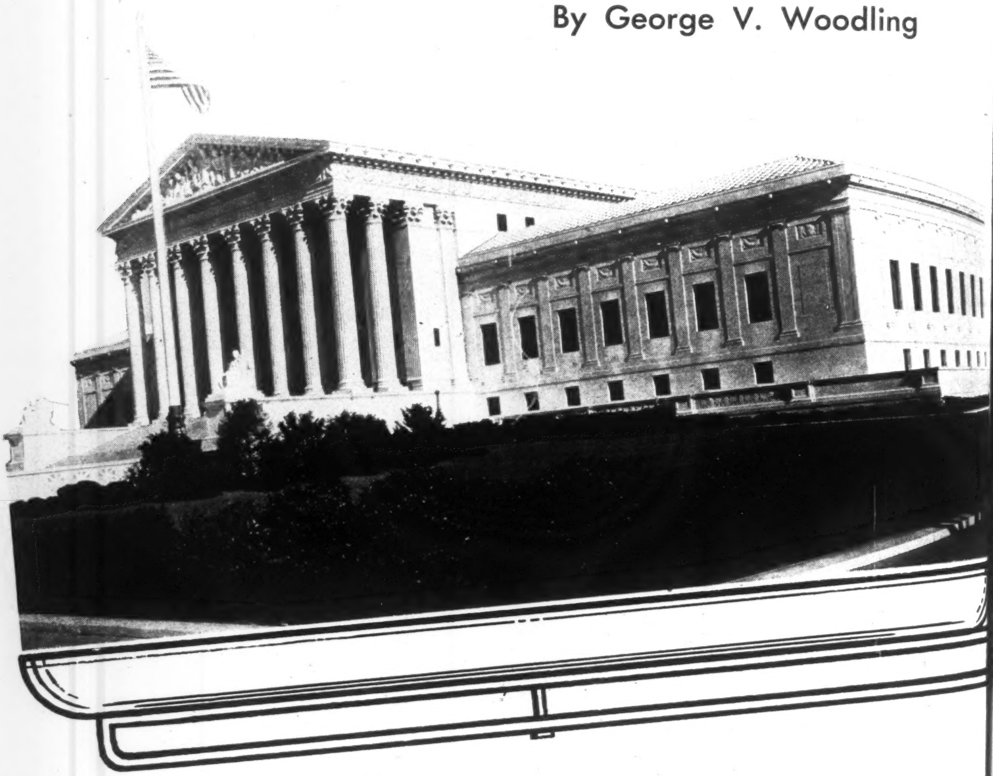
5. MACHINE DESIGN, Feb., 1940, Page 40.
6. "*Deflection of Helical Springs Under Transverse Loading*"—Burdick, Chaplin and Sheppard, *Transactions*, A.S.M.E., 1939, Page 623.
7. Lehr—*Die Federn*, Page 100, 1938, VDI Berlin.

Shall Courts or Congress Cha

By George V. Woodling



CHANGES which define the trend in patent law are governed not only by Congressional legislation but also by judicial legislation. Judicial legislation is a term which has been applied to those decisions of the courts, particularly the Supreme Court, which have substantially the same effect, as far as the administration of the law is concerned, as legislation enacted by Congress.

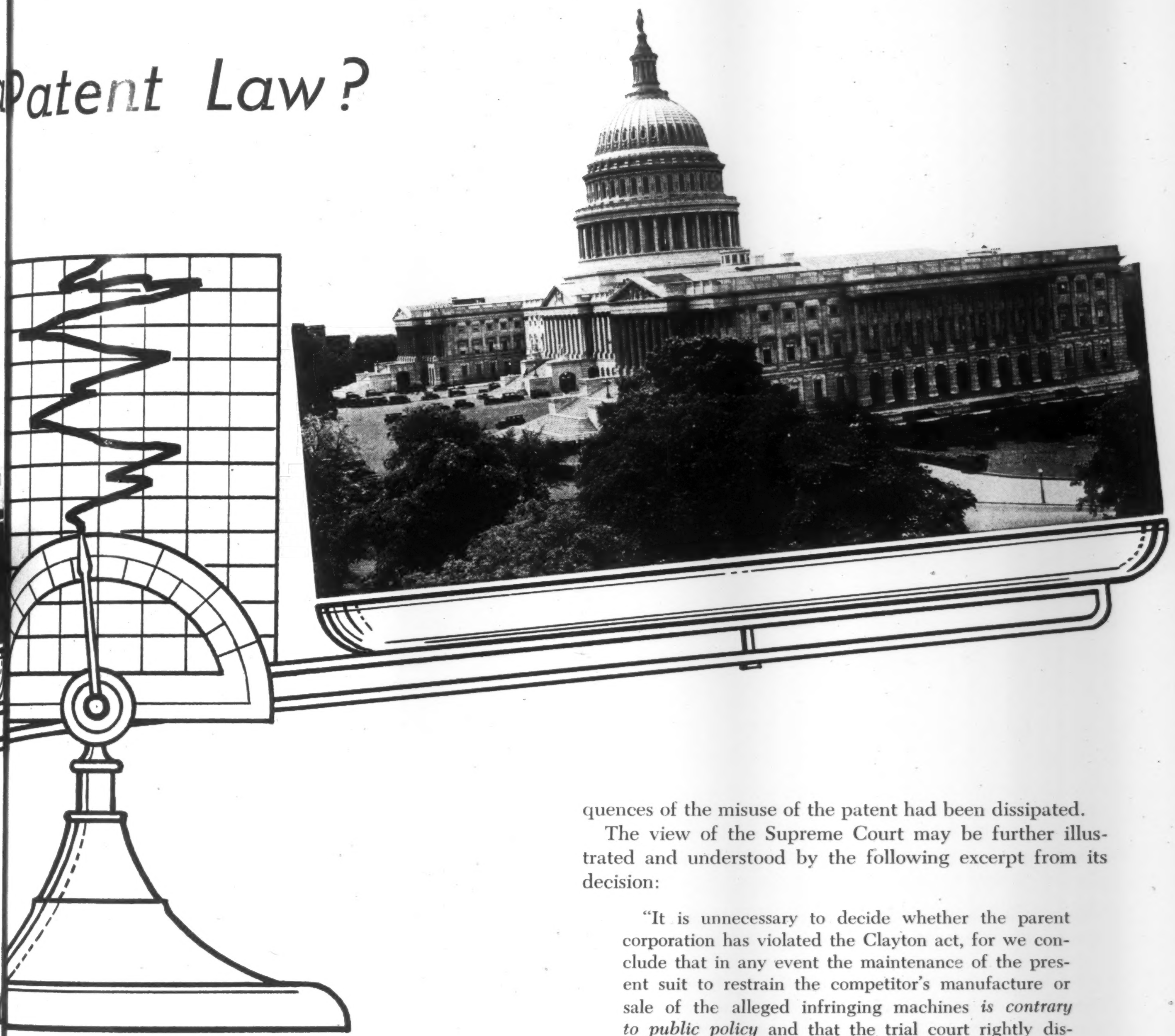
How judicial legislation functions may be explained by reviewing a case decided by the Supreme Court on Jan. 5, 1942, involving the salt tablet dispensing machine shown in *Fig.* 1. This machine is particularly useful in the canning industry for adding predetermined amounts of salt in tablet form to the contents of the cans before they are sealed. The dispensing ejector is operated in accordance with the movement of the cans on the conveyor.

The patent for this dispensing machine belonged to a corporation which owned a subsidiary company that manufactured salt tablets. The salt tablets were unpatented, but had a particular configuration rendering them convenient for use in the patented dispensing machine. The principal business of the subsidiary company was the sale of these salt tablets. In conjunction with the subsidiary business the parent corporation leased its patented machines to commercial canners, some two hundred in all, under licenses with the agreement that only the subsidiary's salt tablets be used with the leased machines.

A competitor started to manufacture and lease a similar salt-dispensing machine to commercial canners. The competitor also sold salt tablets. The parent corporation sued the competitor for direct infringement of the patent. Without passing on the issues of validity and infringement of the patent, the trial court took the ground that the parent corporation was making use of the patent to restrain the sale of salt tablets in competition with its own sale of tablets by requiring the licensees to use with the patented machines only tablets sold by the subsidiary. The parent corporation took the case to the Court of Appeals, which reversed the decision on the grounds that the parent corporation's use of the patent was not shown to violate the Clayton (antitrust) act as it did not appear that the use of the patent substantially lessened competition or tended to create a monopoly, for the total amount of salt used in the two hundred machines was an infinitesimal proportion of all salt sold in this country. (The Clayton act authorizes those injured by violations tending to lessen competition or create a monopoly to maintain suit for treble damages and for an injunction in appropriate cases.)

The case was taken to the Supreme Court, which decided to hear it because of the public importance of the

Patent Law?



question presented. The suit was for infringement of the patent and the Supreme Court pointed out that the question which it was called upon to decide was not necessarily whether the parent corporation had violated the Clayton act, but whether a Court of Equity should lend its aid to protect the patent on the machine when the parent corporation was using it as an effective means of restraining competition with its sale of nonpatented salt tablets.

Aid Denied Because of Misuse

In rendering its opinion the Supreme Court held that the parent corporation should be denied the aid of the courts in stopping the competitor from infringing its patent and that the aid of the court should be withheld at least until it was made clear to the courts that the licensing restrictions requiring the licensees to use only the subsidiary's salt tablets had been abandoned and the consequences of the misuse of the patent had been dissipated.

The view of the Supreme Court may be further illustrated and understood by the following excerpt from its decision:

> "It is unnecessary to decide whether the parent corporation has violated the Clayton act, for we conclude that in any event the maintenance of the present suit to restrain the competitor's manufacture or sale of the alleged infringing machines *is contrary to public policy* and that the trial court rightly dismissed the complaint for want of equity."

This decision, by judicial legislation, takes away a right which the patent owner formerly had under the laws as enacted by Congress pursuant to the Constitution of the United States. In other words, a patent gives the patentee a right to sue infringers to stop infringement of his patent, but this decision takes from the patent owner the right to sue if at the same time it is found that the patent is used to create a monopoly upon unpatented articles.

Monopoly Not Sanctioned

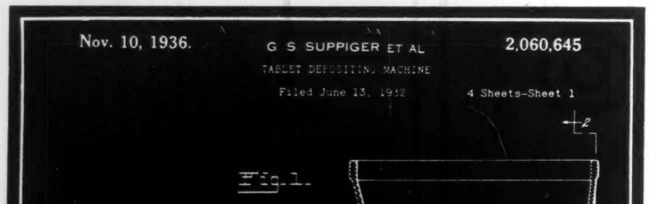
The Court justifies its position in this case upon the ground that should it give its aid to the parent corporation in stopping the competitor from infringing the patent on the machine, it would in effect be aiding in the creation of a limited monopoly in the tablets which do not come within the monopoly granted by the patent upon the machine. A patent operates to create in the patentee the right to exclude others from using the particular device described and claimed in the patent; but the patent affords no immunity for a monopoly not within the grant of the patent. The Court argues further that to give aid to the parent corporation would be against public policy or public interest.

It is of interest to note the language of the court involving the question of public interest:

> "Undoubtedly 'equity does not demand that its suitors shall have led blameless lives', but additional considerations must be taken into account where maintenance of the suit concerns the public interest as well as the private interests of suitors. Where the patent is used as a means of restraining competition with the patentee's sale of an unpatented product, the successful prosecution of an infringement suit even against one who is not a competitor in such sale is a powerful aid to the maintenance of the attempted monopoly of the unpatented article, and is thus a contributing factor in thwarting the public policy underlying the grant of the patent."

The sweeping effect of this decision may be far-reaching if the same general view is entertained by the Court in deciding subsequent cases. Conceivably one may expect that this judicial doctrine might spread to include cases which prohibit the patentee from suing if at the same time it is found, for example, that he has refused to grant licenses under his patent. The extension of judicial legislation to such a point would in effect be equivalent to the principle of compulsory licensing. Unless reversed by the Supreme Court itself, this decision may make it unnecessary for Congress to enact any legislation to reform the patent laws to obviate certain alleged abuses involving patent licensing now claimed to constitute sore spots in the patent system.

Fig. 1—Supreme Court decided salt machine case on basis of public interest rather than of patent law, thereby introducing judicial legislation



Congress Unable to Enact Legislation

It is interesting to note that the Supreme Court accomplished what Congress was unable to do by legislative action. Thus a bill which was recently before Congress (S-4442) contained provisions substantially in line with the views expressed by the Court in the salt dispensing machine case but failed to receive sufficient support to be enacted. The bill reads substantially as follows:

> "It shall be a complete defense in any suit for infringement of a patent to prove that the complainant in such suit is using or controlling the said patent in violation of any law of the United States relating to unlawful restraints and monopolies or relating to combinations, contracts, agreements or understandings in restraint of trade, or in violation of the Clayton act or of the Federal Trade Commission act."

To do by judicial opinion what could not be done by legislative enactment is substituting the policy of the Court for that of the legislative body of the people. Judicial legislation runs counter to pure democratic ideals and is predicated upon the assumption that the American people are incapable of reasoning for themselves and that the democratic processes of changing laws are too slow. The proper functions of the Court are to interpret the law and avoid delving into questions of public policy. Throughout the years the Supreme Court has been careful about assuming unwarranted authority or leadership in those cases touching upon questions of public policy.

Previous Attitude Is Contrast

Attitude of the Court in the past may be further found in the statement of Mr. Justice Harlan, speaking for the Supreme Court in a case which he wrote on May 28, 1900:

> "This court has nothing to do with questions of mere *policy* that may be supposed to underlie the action of Congress. What is termed the *policy* of the government in reference to any particular subject of legislation, this court has said, 'is generally a very uncertain thing, upon which all sorts of opinions, each variant from the other, may be formed by different persons. It is a ground much too unstable upon which to rest the judgment of the court in the interpretation of statutes.' . . . . 'Our province is to *declare what the law is,* and not, under the guise of interpretation or under the interpretation of what may be surmised to be the policy of the government, so to depart from sound rules of construction as in effect to adjudge that to be the law which Congress has not enacted as such.' . . . . *'Our duty is to give effect to the will of Congress, as thus plainly expressed.'* "

It is quite apparent that the Supreme Court in deciding the salt case permitted itself to be guilty of the practice of overriding the will of Congress, which it has from time to time condemned.

The indulgence of the Court in this practice of attempting to evaluate public policy appears to be more frequent at the present time than it has been in the past, and has caused their decisions to be looked upon as constituting a trend in the general direction of curtailing patents. The direction of this trend is particularly observed in a recent case—decided on Dec. 7, 1942—involving the transformer shown in Fig. 2 which readily acquired wide commercial acceptance.

Licensee Claimed Patent Invalid

Many manufacturing licenses were granted under this patent and each of the licenses contained a clause involving "price fixing." One of the licensees failed to make royalty payments and the owner of the patent sued the licensee for back royalties; he also asked for an injunction restraining further sales of the transformer except in terms of the license agreement. The licensee defended the case upon the ground that the broad claims (covering the transformer upon which the unpaid royalties were alleged to be due) were invalid. The main question involved in this case was whether a licensee by virtue of his license agreement is legally prevented from challenging a price-fixing clause in the agreement by showing that the license agreement is invalid and that the price restriction is accordingly unlawful because not protected by the patent monopoly. It is to be remembered that a restriction on the price of articles in interstate commerce is a violation of the Sherman act unless it is within the protection of a valid patent. The licensee contended that he had a right to question the validity of the patent because, if the patent could be declared invalid by the court there would be no qualified patent upon which to predicate a price-fixing agreement and the license agreement would be brought squarely within the Sherman act.

The Supreme Court held in this case that the licensee had a right to attack the validity of the patent involved. notwithstanding the fact that it had been well recognized for years that a licensee sued for royalties could not raise a defense that the licensed patent was invalid. Here again the Court justified its position upon the ground of public interest. This decision, since it substantially overruled what formerly was considered well-established law, has been characterized as "startling" to the patent profession.

Licensee Should Not Attack Validity

The logic upon which the formerly recognized law was based may be explained as follows: One who acquires a license would not do so if he thought the patent was invalid. The acquiring of a license is a legal admission that the patent is valid and the licensee having made his bargain is bound to honor or live up to it during the continuance of the agreement, which precludes him from attacking the validity of the patent.

If the salt decision and the transformer decision can be taken as indicating the trend of the Supreme Court, one may reasonably expect that judicial legislation will take a great part in reforming the patent laws. One may draw the conclusion from these decisions and others of the Supreme Court that the justices are more sensitive to public opinion than are the members of Congress. When loud demands are made to change the patent laws and when sufficient unremitting agitation has been stirred up, one can be sure that either Congress or the Supreme Court will respond to the pressure causing the demand. In this sense Congress and the Supreme Court act as valves to relieve excessive pressures generated by public interest.

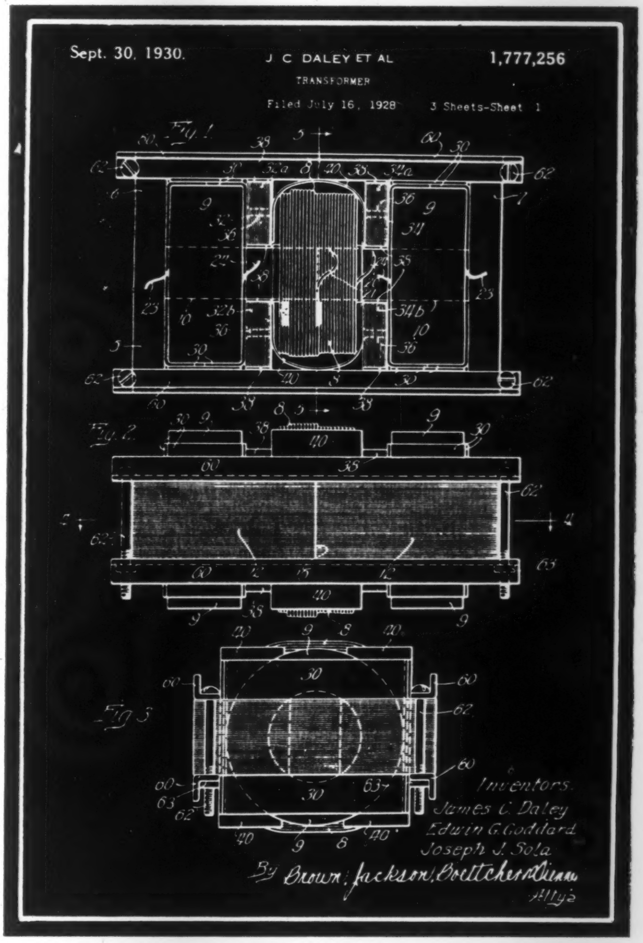


Fig. 2—Licensee's right to question validity of transformer patent was upheld by Supreme Court, effect being to overrule formerly recognized law

Since the beginning of our statutory patent system in 1836, many amendments, changes and conflicting decisions have made it advisable to regroup the existing laws. This was last done in 1925. Thus while the laws have been regrouped a few times, there have never been any serious efforts, backed up by intelligent study, to redraft the patent laws in the light of existing industrial conditions. Things have been left more or less to the Supreme Court and the other courts to cure the deficiencies by judicial legislation. It might be said that charting of the trend has passed to the courts through default.

To restore legislation in patent reform back to Congress where it belongs requires extensive research and prolonged study of the existing patent laws in the light of industrial conditions to determine what constitutes the abuses in the patent system and to draft legislation to cure them. The study of these problems should be tied up with a program of education so that Congress would have sufficient and proper information upon which to draft adequate laws to protect the patent system and improve its method of operation.

WVXS. PQD
JCQD. NYGD
46B18c
46B17(INT)
QQ-B-671a
AN-QQ-A-671
E-QQ-B-671a
57-52A

Worried About Specifications? Here's Washington Answer

By Carter S. Cole
Chief, Metals Section
Conservation Division
War Production Board

MANY manufacturers engaged in the making of war material are frequently confronted with the problem of interpreting Navy, War Department and Federal specifications and securing material to conform with them. Proper procedure to follow to secure authorization for making substitutions is still obscure. The accompanying article has therefore been prepared by the War Production Board at MACHINE DESIGN'S express request to assist machinery manufacturers over the hurdles of specification and substitution of materials

WAR conditions have imposed on manufacturers many unfamiliar requirements due to the Government having become almost the sole buyer of industrial output. Army, Navy, Federal and Maritime procurement agencies purchasing equipment have been using their own specifications, developed over a long period of time. Many new specifications have been written—some as amendments, some as emergency alternates, some (in the case of the Navy) as "ad interim" specifications.

Even before the war there was a multiplicity of specification-writing bodies. With the specifications of the American Society for Testing Materials, the Society of Automotive Engineers, and the American Iron and Steel Institute, most manufacturers were familiar. However, the many and varied Government specifications issued from numerous different sources have led to the bewilderment of engineers in companies undertaking Government contracts.

The basic Government specifications are the Federal specifications issued by the Federal Specification Executive Committee. A complete index of these is published in the Federal Standard Stock Catalog, which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C. A typical Federal Specification reference would be specification QQ-B-671a, Amendment 1, July 30, 1942, for "Bronze, aluminum; castings." The first two letters (QQ) designate the group in which the specification is classified, in this case "metals." (This group designation may be a single letter, or the letter may be repeated twice as in this instance, or three times. The GGG group, for example, covers "tools".) The next single letter (B), which is always single, is the alphabetical index of the subject in the specification—in this case "bronze". The number (671) identifies the particular specification, within any group. These numbers are not consecutively assigned. The small letter (a) denotes a revision. Minor changes are covered by amendments printed on green paper to call attention to the fact that they are amendments. The date, of course, is the date of issue. Emergency alternates use the prefix E before the specification number and also carry a date. Thus, the Emergency Alternate for the Aluminum Bronze Casting Specification is E-QQ-B-671a, May 6, 1942. These Emergency Alternates are not mandatory but may be used on an optional basis by the purchasing officer, if he considers the emergency alternate material a suitable substitute for the particular purpose at hand. Emergency Alternate Specifications have heretofore been mimeographed, but in the future will be printed in the same size as the standard Government Specifications (5 inches by 7¾ inches) but on pink paper.

The Army and Navy Aeronautical Board has accepted certain of these Federal Specifications for aircraft procurement, and the specification number is then preceded by the symbol AN. A large number of specifications also have been written with classifications the same as the Federal Specification classification would be, but for which there is no Federal Specification. For instance AN-QQ-A-671 is the Army-Navy Aeronautical Specification for "Anodes, cadmium," but there is no

Down-Grading Chart for Brass and Bronze Castings

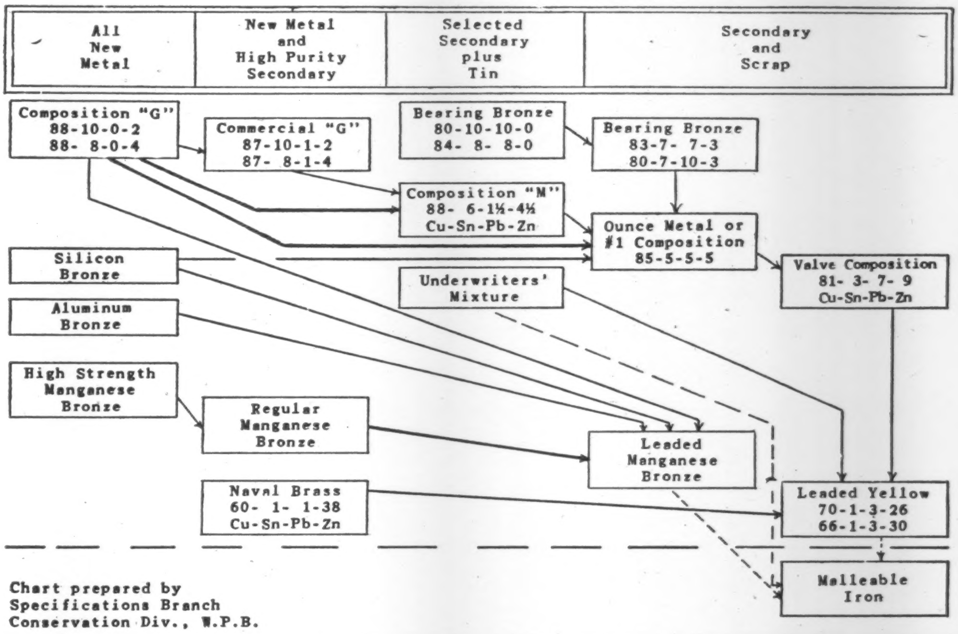

All New Metal
New Metal and High Purity Secondary
Selected Secondary plus Tin
Secondary and Scrap
Composition "G" 88-10-0-2 88- 8-0-4
Commercial "G" 87-10-1-2 87- 8-1-4
Bearing Bronze 80-10-10-0 84- 8- 8-0
Bearing Bronze 83-7- 7-3 80-7-10-3
Composition "M" 88- 6-1½-4½ Cu-Sn-Pb-Zn
Ounce Metal or #1 Composition 85-5-5-5
Silicon Bronze
Aluminum Bronze
Underwriters' Mixture
Valve Composition 81- 3- 7- 9 Cu-Sn-Pb-Zn
High Strength Manganese Bronze
Regular Manganese Bronze
Leaded Manganese Bronze
Naval Brass 60- 1- 1-38 Cu-Sn-Pb-Zn
Leaded Yellow 70-1-3-26 66-1-3-30
Malleable Iron

Chart prepared by
Specifications Branch
Conservation Div., W.P.B.

SPECIFICATIONS

ALLOY	ASTM	ARMY & FEDERAL	NAVY	AMS	SAE
Composition "G"	B 143, 1A & 1B B 60	QQ-B-691a - 5	46M 6g "G"	4845 A	62
Commercial "G"	B 143, 2B E-B 143, 2X	QQ-B-691a - 6	46B 5h "P-c"		
Composition "M"	B 143, 2A B 61	QQ-B-691a - 1	46B 8g "M"		
85-5-5-5	B 145, 4A B 62	QQ-B-691a - 2	46B23c "Oz-c"		40
81-3-7-9	B 145, 5A	QQ-B-691a -11	46B24d		
80-10-10	B 144, 3A			4842	64
84- 8- 8	E-B 144, 3Y	QQ-B-691a - 8	46B22d "II"		
83- 7- 7-3	B 144, 3B	QQ-B-691a - 12			660
80- 7-10-3	E-B 144, 3X				
Naval Brass	B 146, 6C	QQ-B-621 - A	46B10f "N-c"		
70- 1- 3-26	B 146, 6A E-B 146, 6X & 6Y	E-QQ-B-621 X & Y	46B11 (Int.)		
66- 1- 3-30	B 146, 6B	QQ-B-621 - B	46B11 (Int.)		41
Silicon Bronze		QQ-C-593	46B28 (Int.)		
Aluminum Bronze	B 148, 9A & 9B	QQ-B-671a	46B18c		68
Underwriters' Mixture		WW-C-621a	34F 3c		
H. S. Manganese	B 147, 8B	QQ-B-726b B & C	46B29 "MA-c"	4862	
Regular Manganese	B 147, 8A	QQ-B-726b - A	49B 3e "Mn-c"	4860	43
Leaded Manganese	B 147, 7A	QQ-B-726b - D			

NOTE: Specifications, as shown, are approximately equivalent but may not in all cases be interchangeable for procurement and inspection.

TABLE I

Available in Insufficient Quantity

List I a
Magnesium
Aluminum
Copper
Tin
Cadmium
Zinc
Bismuth

List I b
*Tantalum
Beryllium
Lithium
Iridium

List I c
*Molybdenum
*Nickel
*Vanadium
*Tungsten
*Chromium
Cobalt
Calcium Silicon

List I d
*Chrome-Nickel Stainless Steel
*Straight Chrome Stainless Steel
AISI Alloy Steel
NE Alloy Steel
Tool Steel; High Speed
Low Phosphorous Pig Iron
Alloy Cast Iron

List I e
Steel Products:
  *Bars, 1½ inches or larger†
  *Forgings
  *Seamless Tubing
  *Plates
  Sheet and Strip
Bars, under 1½ inch†
Wire Rope
Wire Products
Castings
Tinplate
Galvanized Sheet

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*Most critical. Materials in each subgroup are listed in order of criticalness.
†Except reinforcing.

TABLE II

Available in Limited Quantity

List II b	List II c	List II d	List II e
Rhodium	Calcium	Tool Steel, except High Speed	Steel Products:
Platinum	Columbium	Open Hearth Carbon Steel	Black and Terne Plate
Ruthenium	Ferrotitanium	Cast Iron	Pipe
Mercury	Zirconium and Alloys	Malleable	Rails
Silver	Silicomanganese	Gray Cast	Structural
Palladium	Ferrosilicon	Pig Iron, except Low Phosphorous	Piling
Indium	Spiegeleisen	Bessemer Steel	Wire Mesh Reinforcing
	Silvery Iron		Reinforcing Bars
			Rerolled Rail Products

Note: Materials in each subgroup are listed in order of criticalness.

Federal Specification QQ-A-671. A new series of joint Army and Navy specifications based on Federal classification has recently been started. These will carry the designation AND before the Federal Specification symbols and designation.

The Army has for years used a standard series of specifications based on groupings by classes and class numbers, followed by a number to designate a particular specification. In this series Class 57, for instance, denotes "metals, ferrous and nonferrous and products thereof not otherwise assigned". For example, specification 57-52A is the specification for aluminum bronze ingots for remelting. These series include specifications issued by the Quartermaster Corps, Medical Department, Corps of Engineers, Ordnance Department, Signal Corps, Chemical Warfare Service, Army Air Corps, and Coast Artillery Corps. An index of these specification's also can be obtained from the Superintendent of Documents in Washington.

Tentative specifications issued by various Quartermaster and Medical Depots can be obtained from the depot of origin and are designated by key symbols (followed by a simple number) as follows:

PQD	Philadelphia Quartermaster Depot
CQD	Chicago Quartermaster Depot
BQD	Boston Quartermaster Depot
JQD	Jeffersonville Quartermaster Depot
JCQD	Jersey City Quartermaster Depot
SFGD	San Francisco General Depot
NYMD	New York Medical Depot
NYGD	New York Medical Depot
OQMG	Office of the Quartermaster General
SLMD	St. Louis Medical Procurement District

The Ordnance Department, Washington, issues tentative specifications carrying key symbols AXS and the six manufacturing arsenals also issue tentative specifications with the key symbols as shown below:

FXS	Frankford Arsenal
PXS	Picatinny Arsenal
RIXS	Rock Island Arsenal
SXS	Springfield Arsenal
WXS	Watertown Arsenal
WVXS	Watervliet Arsenal

While the Army in addition to their own specifications uses Federal Specifications for many purchases, the Navy more generally writes its own, although they too use Federal Specifications.

The Navy follows somewhat the same system of classification as the Federal Specifications, but uses a different system of nomenclature. In the Navy list the specification for Aluminum Bronze Castings is 46B18c, August 1, 1934. The 46 is the group number for "Metal in Bars, Billets, Ingots, Pigs, Slabs, etc". The letter (B) is again the alphabetical index of the subject. The number (18) is the serial number of the specification, the small letter (c) indicates the revision, and the date is the date the specification was issued. To expedite revision of the specifications, the Bureau of Ships of the Navy Department has issued a number of "ad interim" specifications. In these the small letter indicating revision is replaced by the letters (INT). The specification for Aluminum Bronze Bars, for instance, is known as 46B17 (INT), dated May 15, 1942.

An index of the Navy Specifications is obtainable from the Superintendent of Documents in Washington. This covers the regular specifications but not the ad interim ones.

A number of other government departments issue specifications, most important of which are those of the Procurement Division of the Treasury which makes purchases for many Government departments. The Forest Service of the U. S. Department of Agriculture also issues specifications for fire-fighting equipment, and there are others.

Although readers of MACHINE DESIGN could make good use of a cross index of equivalent specifications, the foregoing review of some of the government specification-writing bodies indicates what an impossible task the compilation of such an index would be under present conditions. Then, too, on the side of commercial specifications, it will be noted that no mention has been made of the Aeronautical Materials Specification (AMS) or the specifications for the National Emergency Steels (NE). However, the above outline of the various sources of the specifications will enable the reader to track down the specification he needs, find out who issued it and obtain a copy.

TABLE III

Available in Significant Quantities

Antimony	Gold
Antimonial Lead	Lead
Ferroboron	Osmium
Ferromanganese	

Note: Order of listing is alphabetical and does not reflect criticalness.

In the last war there was a shortage of raw materials such as copper, but the problem was by no means as

(*Continued on Page* 190)

Wartime Metallurgy Conserves Strategic Materials

Part X—Case Carburizing

By **R. E. Orton** and **W. F. Carter**
Acme Steel Co., Chicago

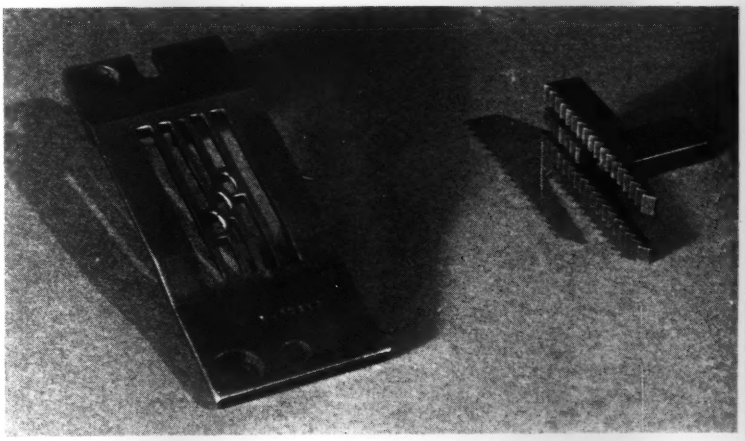

Fig. 81 — Feed dog (right) and throat plate for industrial sewing machine are case-hardened free-machining steel. These parts could not have been economically made from through-hardening steel. Photo, courtesy Union Special Machine Co.

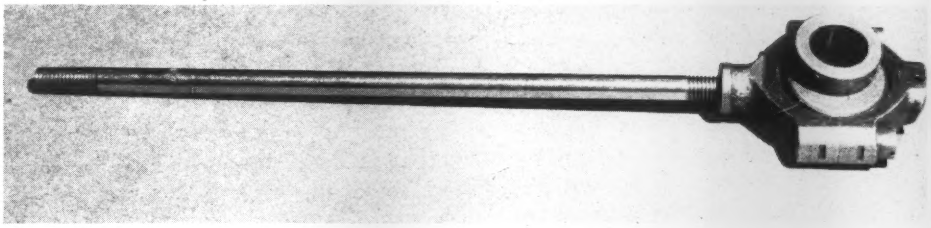

Fig. 82—Case hardening of the free-machining steel used in feed bar for industrial sewing machine provides the required fatigue resistance. Photo, courtesy Union Special Machine Co.

DURING the war emergency, case-hardening processes make possible considerable conservation of strategic alloy and high-carbon steels. Locating blocks, clamps, screws and bushings on jigs and fixtures; guides and supports on die parts; and similar pieces on other tools normally made from tool steels, through-hardened, are being satisfactorily and economically replaced by plain low-carbon case-hardened parts. This conservation may also be extended to many other parts with little, if any, increase in cost or loss of utility and with the advantage of using more easily obtainable steels and the satisfaction of a worthwhile contribution to the war effort.

One of the oldest and probably the most universally useful methods of hardening, the process makes use of material not in itself particularly suited to heat treatment; it changes the chemistry of the surface, either making this surface hard or making it susceptible to hardening processes. The utility of the process lies in many diverse features, depending upon the application. For many it makes possible the use of a free-machining (*Fig.* 81) or forming (*Fig.* 39, M. D., December, 1942, Page 92) steel, followed by the production of a surface suitable for hardening. This hardening may be for the purpose of improving wear qualities, as in the above illustrations, or for improving the strength of the piece, as in the case of *Figs.* 82 and 83.

For certain other typical applications, where perhaps an extremely thin hard skin is all that is required (*Fig.* 84) it will be the cheapest method, or will give the most wear-resistant surface (1, 2, 4)*. Again, with relatively heavy cases, a part is obtained which, it is felt by many, in some measure combines the desirable features of ductility and impact resistance of the core with wear and strength qualities of the case. Noteworthy among such applications are gears as shown in *Fig.* 85 and referred to in (3) and (4).

The viewpoint just stated is being abandoned by many authorities, although a considerable body of opinion still holds to it. If a fracture of the case does not constitute failure, nor will lead to it, it is justified. In most applications, however, case fracture either constitutes failure in itself, or is the beginning of a fatigue crack that leads to failure. Under such circumstances it is difficult to see what value the "soft ductile" core constitutes.

In probably no other method of hardening is it so easy, by careless specification of the various phases of the processing and by a profligate choice of material, to increase the costs and add to the manufacturing difficulties. The very flexibility of the methods and their wide variety which makes them so useful, carries with it this danger. This means that the engineer reponsible for such specifications must understand well what it is that he is asking for, and exercise a strong restraint against haphazard selection.

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*References in parentheses are listed at end of article.

Outstanding methods of accomplishing this hardening are either by increasing the surface carbon content and then quenching (5, 6), or by adding nitrogen to the surface which affords hardness without the necessity of a quench (1, 2, 7), or by a combination of these two (8, 9, 10). This alteration in the surface chemistry may be accomplished by packing the parts in a solid compound, by immersing in a suitable liquid, or by surrounding by a gaseous atmosphere; all, of course, at a sufficiently high temperature to accomplish the reaction. These processes are well covered in Reference 11. All processes are suitable for continuous or batch operation, or any quantity.

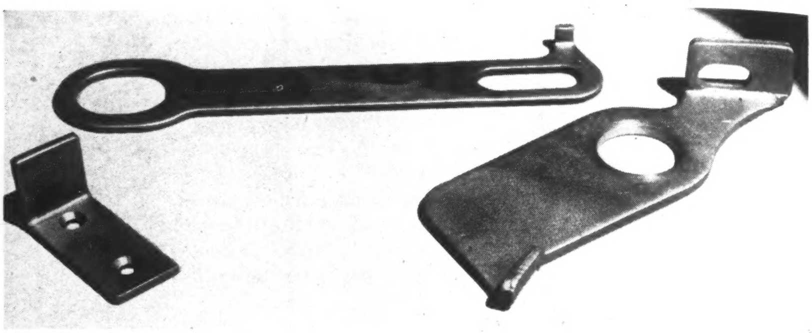
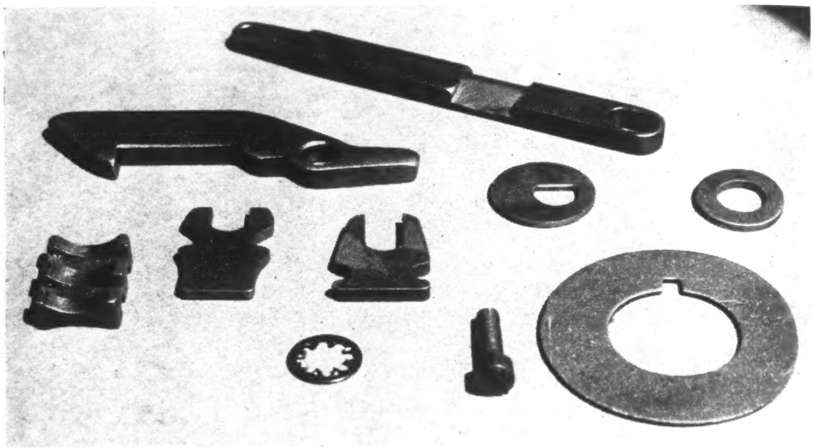


Fig. 83—Soft, easily formed rimming steel is necessary for the fabrication of these parts for a steel strapping machine. Case hardening provides sufficient strength

Fig. 84—Below—Thin hard case, cheaply provided on these parts, prevents surface scuffing, thread wear, damage to screw-driver slot, etc.



The oldest and probably still the most widely applied method is to pack the part in a compound which consists primarily of some carbonaceous material such as hardwood charcoal, together with an activating catalyst, frequently barium carbonate. The basic chemistry is relatively simple. Carbon, in the presence of an insufficiency of oxygen, burns to CO. The CO gas at the surface of the hot steel reacts to produce atomic carbon, reaction being

$$2\,CO \longrightarrow CO_2 + C$$

Gamma iron dissolves atomic carbon (*Fig.* 25, M.D., October, 1942, Page 72), increasing the surface carbon content. The carbon then diffuses inwardly toward regions of lower carbon content. The CO_2, circulating back to the incandescent carbon, reverses the above reaction to form more CO. Thus the CO gas radical acts as a carrier medium to convey the carbon from the solid source to the steel surface.

Parts to be carburized are packed in metal boxes with the proper mixture of carburizing compound surrounding the parts. The boxes are then charged into a furnace, heated to the carburizing temperature, and held until sufficient penetration of the carbon has occurred. This time will depend upon many variables — nature of the compound, type of steel, temperature, etc. Representative figures are, at 1700 degrees for a low carbon unalloyed steel, .03 depth in two hours, .06 in eight hours, and .12 in twenty-four hours.

Carbon content and depth of the case will depend upon reaction temperature, analysis of the compound, and analysis of the steel. In general, lower carburizing temperatures drop the diffusibility more than the rate of pickup, resulting in higher surface carbon and sharper carbon gradients from surface to core. Higher temperatures tend to the reverse. By proper balance of the compound and temperature, surface content may be controlled.

It may be seen that pack carburizing is a very crude process. Most important variable is undoubtedly the temperature. The carburizing compound is, in itself, an excellent heat insulator, so that the center of the box comes to temperature after the outside. As a result, not only will a variation be observed between pieces so located, but on larger pieces a variation will be noted from one end to the other. It is difficult to control the analysis of the compound, and variations will be experienced from batch to batch. The packing of parts in the box requires some skill and thought, as touching parts or irregular compound will give spotty results. Moisture will tend to decarburize, and the smallest amount must be avoided. Control of the case depth within ± .01-inch and surface carbon within .20 to .30 per cent is all that can be expected from commercial work. For this reason the use of box carburizing for depths of .025-inch or less is not recommended. Since packing is the most expensive part of the operation, pack carburizing is not economical for light cases and it is seldom used for less than .05-inch.

It should also be recognized that the chemistry as here presented has been simplified, many points of the process being still in debate (5). Such matters as penetration of the carburizing gas into the steel surface, effect of container metal, method of pickup of the carbon by the steel, etc., all introduce further variables.

It should be noted that, even with a solid carburizer, the mechanism of exchange is gaseous. An early form of gas carburizing, which is still used, was to tumble the work in a rotating retort together with solid compound (7). For work that can stand the rough handling, and for cases of .003-.005-inch, there is a cheap method.

The most prevalent method of gas carburizing, however, resorts to the use of a hydrocarbon gas, either natural, manufactured or prepared. While some CO gas is always present, and furnishes some element of the carburizing action, the great bulk of it comes directly from the hydrocarbon. Probably any hydrocarbon gas will serve (12), the higher carbons breaking down to methane, the methane in turn liberating atomic carbon at the surface of the steel,

$$C_2H_6 \rightarrow CH_4 + C + H_2 \text{ etc.}$$
$$CH_4 \rightarrow C + 2H_2$$

The carbon pickup and diffusion phenomena are the same as with CO.

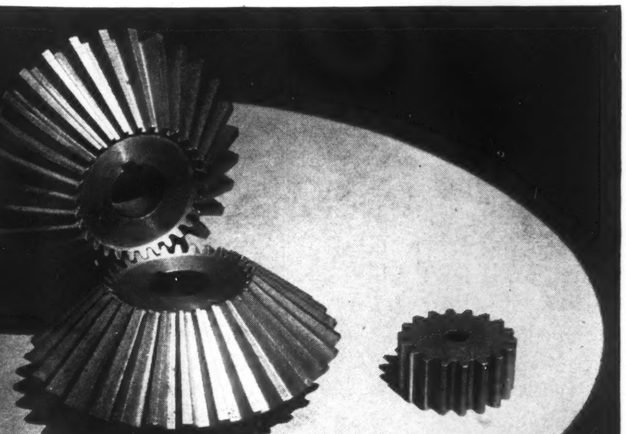
There are two essential differences from the solid carburizing reaction. The hydrogen must be carried away and new methane supplied because there is no incandescent carbon to furnish the "rejuvenating" action.

Use of too high a methane content will result in liberation of C on the steel surface at a faster rate than it can be absorbed and diffused. The excess forms soot or tar deposits. While a light coating will have no further objection than dirty work, a heavy deposit acts to check further carburization. It should also be noted that soot will not protect the steel against any decarburizing action of the atmosphere. It is therefore necessary either to dilute the gas with H_2, burnt flue gas, or other nonactive gases; or to break it off mechanically by tumbling in a rotary retort as is done with some methods of carburizing with natural gas (12).

Many atmospheres are produced by the cracking of a liquid hydrocarbon, a process particularly well adapted to small batch furnaces. *Fig.* 61 (M.D., February, 1943, Page 114) illustrates one make of a popular type of electrically heated furnace provided with forced circulation, the atmosphere being obtained by the cracking of the liquid on a hot target located inside the furnace. By control of the flow of liquid, either a carburizing atmosphere or a protective atmosphere for through-hardening may be obtained. The forced circulation is a highly desirable feature promoting uniformity of work and rapid heating.

Gas carburizing permits of the highest flexibility. Work is quickly responsive to temperature changes, necessitating accurate thermal controls but permitting rapid heating. By varying either the rate of flow or the gas analysis, the intensity of the carburizing action may be readily altered. Aircraft gears are frequently carburized at the maximum rate for about 75 per cent of the cycle, followed by a reduction in the flow to allow diffusion and a reduction in the surface carbon to the eutectoid. This gives a particularly good blending of case and core.

Fig. 85—Below—Case hardening of gear teeth provides a surface well able to withstand abrasion, scuffing, pitting, etc., as well as the contact stresses



The very flexibility of the gas is at the same time its greatest fault for, in unskilled hands, it can result in bad work. In general, for cases say .05-inch and under, the gas method will be the cheaper. For heavier cases the pack method will still probably show at a disadvantage if any weight is given to quality. Present tendency is for the gas method to supplant solid carburizing.

Carburizing temperatures vary from 1550 to 1750 degrees Fahr., depending upon the results desired. Case depths are reported on many different bases, and method of determination should be included in the specification. Common commercial practice is by fracturing a water-quenched part, the core being delineated by the difference in fracture structure or by polishing and etching. One advantage of the batch method is the possibility of removing samples from time to time to check depth. *Fig.* 86 illustrates a good check sample that may be produced cheaply in quantities on a screw machine, and *Fig.* 87 shows the fracture structure. Determination of carbon analysis is not so easy. Best practice in process analysis is a metallographical examination of a slowly cooled sample (see *Fig.* 23, M.D., October, 1942, Page 71). Extremely low analysis may also be caught by a drop in hardenability, as evidenced by a low hardness reading after the quench (M.D., December, 1942, Pages 93 and 94). A spark test will also give a crude check.

Care Necessary in Estimating Case Depth

It should be noted that the case depth as measured by most methods is greater than the depth of full hardness, which is about three-fourths of the fracture test indication. This should be borne in mind when estimating required case depth, particularly where the surface is to be ground.

Case depth required depends upon the nature of the surface loading. For the commonly occurring "contact loads" such as rollers, cams, gears, etc., this may be determined by the application of the usual stress formulas (15). The case structure must be maintained until a depth is reached where the core strength is sufficient to carry the stress (3, 6).

Cooling practice from the carburizing temperature and subsequent heat treating may profoundly affect the end results (3, 13), and probably over no phase of heat treating has there been more argument. Advocates vary from "direct quench from the carburizing temperature" all the way to "slow cool, reheat to over critical of core, quench and reheat to case critical, and quench". If machining is to be done after carburizing there is no argument it will be necessary to slow cool to obtain a machinable case. Carburizing warpage will then be eliminated from the finish-machined surfaces. On those surfaces not machined after carburizing the extra heating operation for the quench will add to the warpage.

One reason for the disagreement lies in the duplex nature of the carburized part—a low-carbon core surrounded by a high-carbon case. Variations with changes in the carbon content have been described in previous articles in this series. A second reason goes back to the days before grain size control and the McQuaid-Ehn test (M.D., January, 1943, Page 62). Coarsening of the grain structure was then to be expected with the long time at the carburizing temperature, and with the higher temperatures then quite prevalent. While this coarse structure would increase hardenability, it would also result in higher warpage, higher residual stress with danger of cracking, and a brittle case. Slow cooling followed by reheating to at least over the critical of the case was therefore considered advisable to refine the case structure, followed by the quench.

This "minimum" practice, however, did not refine the core, nor strengthen it. Morever, if the case carbon content were much above the eutectoid the excess carbide was not absorbed, resulting frequently in an embrittling network structure of carbide. To pick up this carbide it was necessary to go over the "carbide solubility line", *Fig.* 25 (M.D., October, 1942, Page 72); to refine and harden the core it was necessary to go over the core critical. Quenching from this temperature then retained the carbide and strengthened the core. The case, however, was again coarsened, so recourse was had to reheating to just over the critical of the case and again quenching. This is the historic "double-quench", valuable in the days before grain control, superfluous and wasteful with modern grain size controlled steels. Modern practice has swung away from this, favoring instead the direct quench from the carburizing heat with its attendant lower warpage, elimination of the danger of decarburization in the subsequent heating operations, and greater economy. In the direct quench, particularly, the advantage of gas carburizing shows up; parts may be taken directly from the furnace to the quench without the need of opening the boxes and separating from the compound.

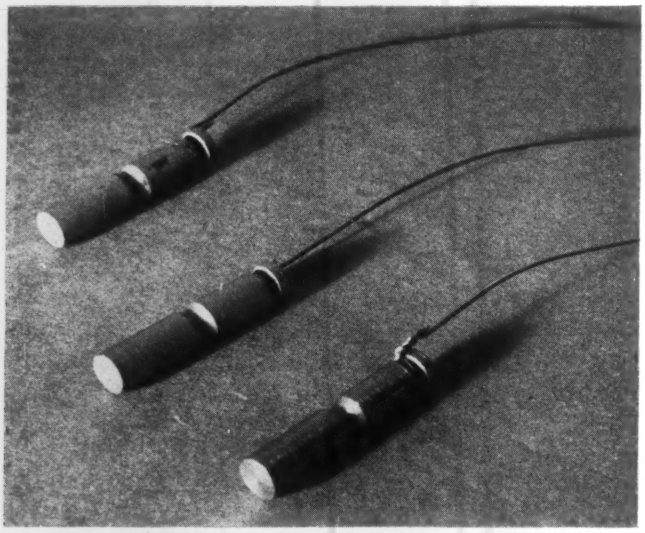


Fig. 86—Carburizing test samples, cheaply made on screw machine and easily fractured, furnish an effective means of checking case depth

Quench will be in oil or water, depending upon hardness requirements, size, etc. (7, 11), as has already been discussed in previous articles of this series, and on alloy content (6, 14), as will be described later. While many lightly stressed parts are used without tempering, it is good practice to give a stress-relieving draw at from 250 to 400 degrees Fahr. from which little if any loss in hardness will occur.

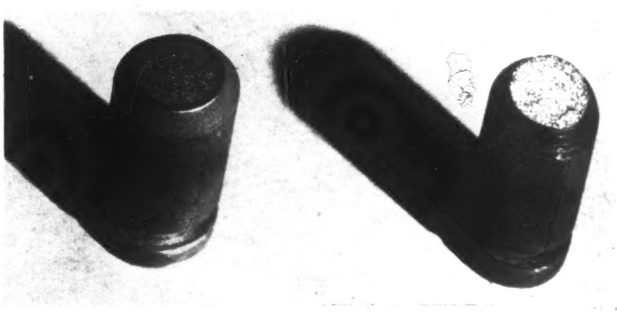


Fig. 87—Carburizing test sample as fractured (right), polished and etched (left). Enlarged 2.1 diameters

A high degree of surface hardness may also be brought about by impregnating with nitrogen or with a combination of nitrogen and carbon. Characteristics of these types of cases, secured by nitriding and cyaniding, and the applications for which they are most suitable will be discussed in the next article of this series.

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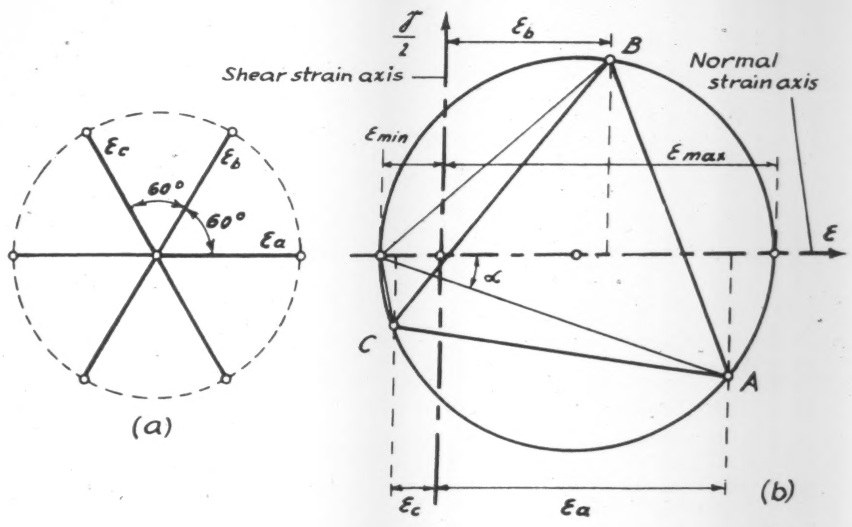
Fig. 1 — Equiangular strain rosette (a) and Mohr's circle for strains (b), constructed from strain measurements


ε_c
ε_b
60°
60°
ε_a
(a)
$\frac{\gamma}{2}$
ε_b
B
Shear strain axis
Normal strain axis
ε_{min}
ε_{max}
ε
α
C
A
ε_c
ε_a
(b)

Simplifying Strain-Rosette Analysis

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RECTANGULAR and equiangular strain rosettes are most commonly used for the investigation of two-dimensional strain and stress. Determination of the direction and magnitude of the principal strains is slightly simpler for the rectangular strain rosette. However, more accurate results may be expected from the equiangular strain rosette because of its more favorable distribution of the gage line directions.

SUPPLEMENTING the article "Strain-Rosette Analysis Is Effective Design Aid" which appeared in the March issue, the following discussion presents a convenient graphical solution for principal strains when strain-gage measurements along equiangular axes are known. The method enables accurate determination of the magnitude and direction of principal stresses at any point in a part where measurements can be made

Both analytical and graphical solutions for the direction and magnitude of the principal strains from the readings of equiangular strain rosettes are available[*]. The graphical solution is generally preferred because it is faster. Methods hitherto described introduce functions of the strain readings as a basis for the graphical construction. In the method here discussed, the readings are plotted directly. Although slightly more graphical work is necessary, the total time required for the solution is about the same or somewhat less, because no adding, subtracting and dividing operations have to be performed.

The direct plotting of the readings and the simple graphical construction can be checked readily. As all three strain readings appear on the plot, the orientation of the principal strains with respect to the strain rosette is particularly clear.

The method of determining direction and magnitude of the principal strains is based on the general theory of Mohr's circle for strains[†]. Three strain readings obtained from an equiangular strain rosette, *Fig. 1a*, correspond on Mohr's circle for strains to three points forming an

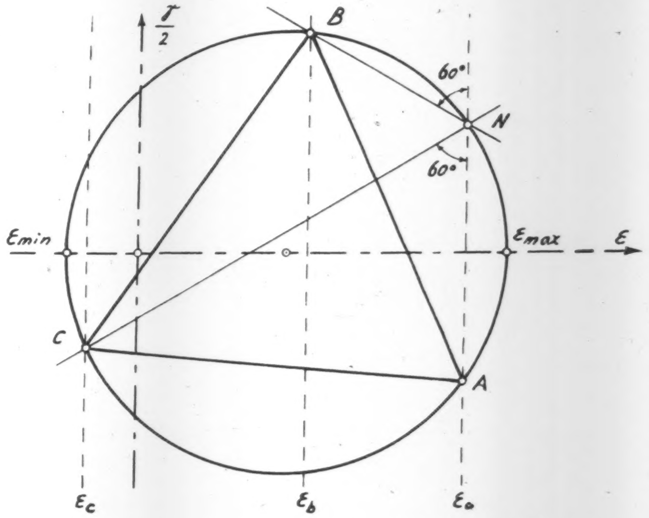
$\frac{\gamma}{2}$
B
60°
N
60°
ε_{min}
ε_{max}
ε
C
A
ε_c
ε_b
ε_a

Fig. 2—Graphical construction of Mohr's circle for strains from measured values

equilateral triangle (*Fig.* 1*b*).

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[*] See the article, "Strain-Rosette Analysis Is Effective Design Aid", MACHINE DESIGN, March, 1943. See also Reference 1 at the end of current article.—ED.

[†] See Reference 2 at end of article.

(Editor's Note: The construction shown is a graphical solution of Equations 10, Page 164, of the article in the March issue. To orient Mohr's circle *Fig.* 1b, with the strain rosette, *Fig.* 1a, it should be rotated counterclockwise until the normal strain axis is at an angle θ_a with the gage line ϵ_a on the rosette, θ_a being equal to the angle α between the normal strain axis and the line from ϵ_{min} to point *A* on Mohr's circle. Mohr's circle construction then represents the basic relation.

$$\epsilon_a = \tfrac{1}{2}(\epsilon_1+\epsilon_2)+\tfrac{1}{2}(\epsilon_1-\epsilon_2)\cos 2\theta_a$$

Origin of this equation is indicated in the development of Equations 7 and 7a of the March article. Similar equations may be written for ϵ_b and ϵ_c, and Equation 10 is derived from the three relations).

Distance from the shear axis to each apex of the equilateral triangle is determined by the observed strains.

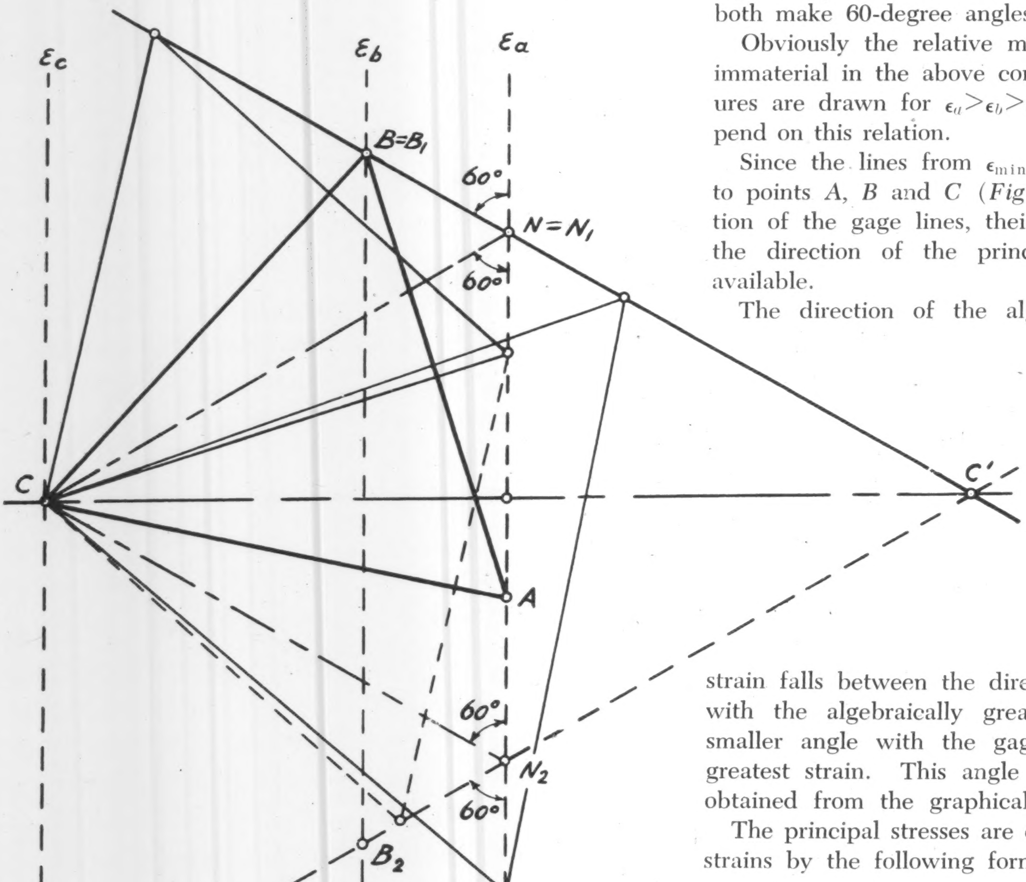

Fig. 3—Construction for finding equilateral triangle with one apex at C, others on parallel dotted lines

The problem of finding direction and magnitude of the principal strains thus consists of finding an equilateral triangle each apex of which is located at a certain known distance from the shear strain axis. The circumscribing circle of this triangle is Mohr's circle for strains—the normal strain axis being determined as passing through the center.

Procedure is as follows: From the strain readings plot the strain lines ϵ_a, ϵ_b, and ϵ_c (*Fig.* 2). Choose point *N* arbitrarily on ϵ_a and draw through this point two lines making 60 degree angles with ϵ_a. Find apex *B* by intersecting one of these lines with ϵ_b and apex *C* by intersecting the other with ϵ_c. Obtain apex *A* on ϵ_a by making *CA* = *BA* = *BC*. Draw circumscribing circle of equilateral triangle *ABC*, which is Mohr's circle for strains with normal strain axis passing through the center.

Basis for this construction is explained thus: If several equilateral triangles are drawn with one apex at point C of strain line ϵ_c and the second apex on strain line ϵ_a, the locus for the third apex is found to be two straight lines (*Fig.* 3). These lines make 60-degree angles with line ϵ_a and pass through point *C'* which is symmetrical to *C* with respect to ϵ_a. The intersection of the locus with strain line ϵ_b furnishes two points B_1 and B_2. Either one of these points may be chosen as apex *B* of the equilateral triangle *ABC* with apexes on ϵ_a, ϵ_b, and ϵ_c.

The triangle determined by point *C* and the intersections N_1 and N_2 of the locus with strain line ϵ_a is equilateral. Thus the lines from *N* to *B* and from *N* to C both make 60-degree angles with ϵ_a.

Obviously the relative magnitude of ϵ_a, ϵ_b, and ϵ_c is immaterial in the above consideration. Although all figures are drawn for $\epsilon_a > \epsilon_b > \epsilon_c$, the solution does not depend on this relation.

Since the lines from ϵ_{min} on Mohr's circle for strains to points *A*, *B* and *C* (*Fig.* 1) correspond to the direction of the gage lines, their orientation with respect to the direction of the principal strains is immediately available.

The direction of the algebraically greater principal strain falls between the direction of the two gage lines with the algebraically greater strains and makes the smaller angle with the gage line of the algebraically greatest strain. This angle α (≤ 30 degrees) is readily obtained from the graphical solution.

The principal stresses are computed from the principal strains by the following formulas:

$$S_{max} = \frac{\epsilon_{max} + m\epsilon_{min}}{1-m^2}E$$

and

$$S_{min} = \frac{\epsilon_{min} + m\epsilon_{max}}{1-m^2}E$$

where S_{max} and S_{min} are the principal stresses, *E* is the modulus of elasticity and *m* is Poisson's ratio, equals .3 for most metals.

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How to Predict Success of Alternative Steels

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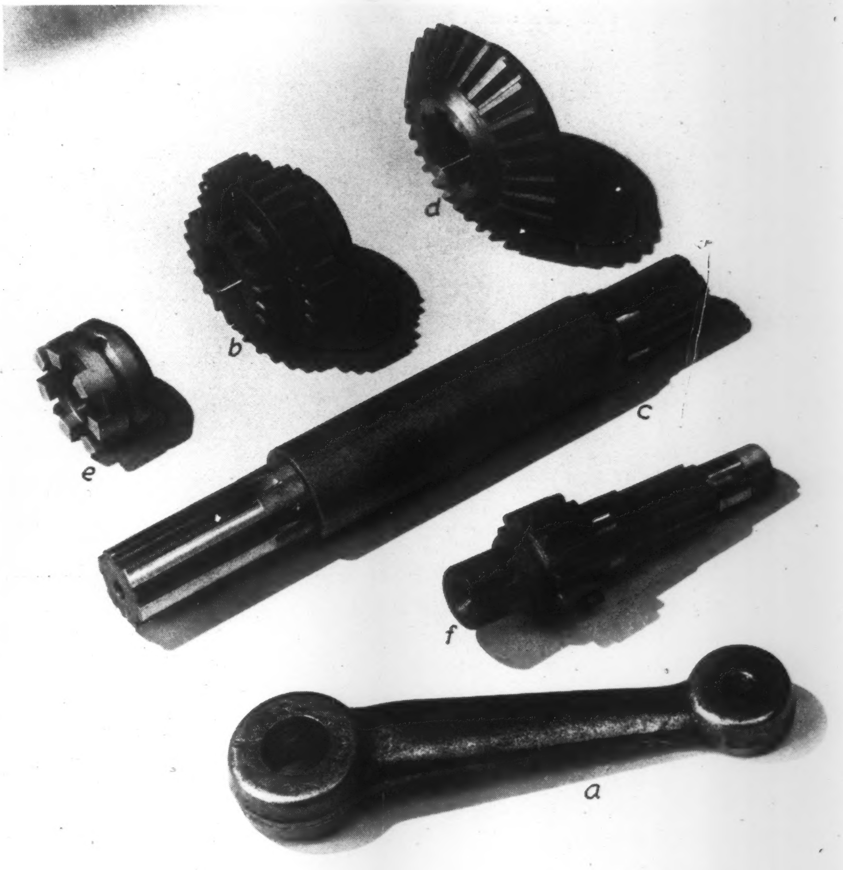

Fig. 1—Low-alloy alternative steels used for these parts have properties substantially the same as those of the replaced materials

DURING the last year design engineers have been faced with the problem of substituting NE steels and carbon steels for the established grades of heat-treatable SAE and AISI alloys. This article deals with several successful examples of such substitutions and also presents a new method of using the end-quench test for hardenability.

In TABLE I are tabulated the treatment and results for the various applications shown throughout the article. The parts are illustrated in *Figs.* 1 and 2. All of the analyses mentioned in the table are familiar[1], with the exception of those used in the spacer and the trunnion (*Figs.* 2*a* and 2*b* respectively). These analyses are listed in TABLE II.

It will be noted that in TABLE I the rockwell C hardnesses for the clash gear (*Fig.* 1*b*), the screw (*Fig.* 2*c*), and the backshaft (*Fig.* 1*f*) are lower when using the new specification than when using the original specification. This is no indication that the new material will not come up to the same hardness if desired, that was specified when the original material was used. In each of these cases it was found that the parts performed equally well at the lower hardness as they did at the higher hardness.

In arriving at the various changes in materials outlined in TABLE I, most of the substitutions were accomplished by the trial and error method. Although this approach gives successful answers it is often costly in that it consumes a great deal of time. Usually the first question that comes to a design engineer's mind is: What will be the hardness and physical properties of an alternative material? How can it be determined, ahead of time, that an alternative will not cause failure of a mechanism? A possible method of determining the physical properties and hardness of an untried analysis of steel for a given section, prior to completion and testing of a mechanism, is to use the drawn or tempered end-quench test. The method about to be described holds true for any alloy or carbon steel which is capable of being fully hardened.

In this approach, use is made of the end-quench or Jominy test pieces[2] after they have been end-quenched in the regular manner and then drawn back or tempered at various temperatures. The curves for SAE 4140 tempered at 600, 800, 1000, and 1200 degrees Fahr. are shown in *Fig.* 3.

By the use of established cooling rates (*Fig.* 4), predicted hardnesses were established for SAE 4140 in sections 1, 2 and 3 inches in diameter. Simultaneously, actual samples of the same steel were heat treated and tested in sections 1, 2, and 3 inches in diameter. The

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[1] See MACHINE DESIGN, Oct. 1942, Pages 150 and 151, also Feb., 1943, Page 110.—ED.

[2] See MACHINE DESIGN, Dec., 1942, Pages 94 and 95.—ED.

TABLE I

Treatment and Results with Alternative Materials

Part Name	Fig. No.	Original Specification				New Specification			
		Analysis	Quenching** Temp F	Drawing Temp F	Rockwell C Hardness	Analysis	Quenching** Temp F	Drawing Temp F	Rockwell C Hardness
Lever Arm	1*a*	SAE 4140	1560-1575	1075-1130	23-29	NE 9445	1560-1575	1090-1150	23-29
Gear*		SAE 3250	1525	1000-1025	34-37	NE 8749	1525	1050-1075	34-37
Clash Gear	1*b*	SAE 4150	1510	500	46-50	NE 8749	1525	500	42-46
Coupling*		SAE 4140	1575	850	42-45	SAE 1045	1600	700-800	42-45
Spacer	2*a*	AMS 5630	1850	1000	38-44	AMS 5120	1450	750	38-44
Shaft	1*c*	SAE 4150	1510	1130	22-27	NE 9442	1550	1130	22-27
Trunnion	2*b*	AMS 5630	1850	1000	38-44	AMS 6322	1525	750-850	38-44
Bevel Gear	1*d*	SAE 4150	1510	500	39-43	NE 8749	1525	800	39-43
Coupling	1*e*	SAE 4150	1510	500	42-46	NE 8749	1525	500	42-46
Screw	2*c*	SAE 4140	1575	575	37-44	SAE X-1335	1550	500-550	30-35
Back Shaft	1*f*	SAE 4150	1510	500	46-50	NE 9442	1550	500	42-46

*Not illustrated. **All parts were cil quenched.

comparison between the predicted rockwell C hardnesses and the actual rockwell C hardnesses is shown in TABLE III.

Referring to the table it is noted that the actual hardnesses run higher than the predicted hardnesses for the 1-inch section with 600-degree Fahr. draw. Upon investigating this discrepancy, it was found that the operator who quenched the actual test pieces agitated them in the regular fashion rather than quenching them in still oil. This accounts for the higher actual values. This, of course, can be interpreted as "engineering good-fortune" because the *actual* values of hardness will be higher than the *predicted* if cooling rates for still media are used in predicting the hardness. Cooling rates can be determined for any degree of agitation in any media.

TABLE II

Per Cent Composition of AMS† Steels

	AMS 5630	AMS 5120	AMS 6322
Carbon	1.00-1.10	.65-.75	.38-.43
Manganese	.60 max.	.70-1.00	.75-1.00
Phosphorus	.04 max.	.04 max.	.04 max.
Sulphur	.04 max.	.05 max.	04 max.
Silicon	.50 max.	....	.20-.35
Chromium	16.5-18.0	....	.40-.60
Molybdenum	.40-.60	....	.20-.30
Nickel	....	....	.40-.60

†Aircraft Material Specification.

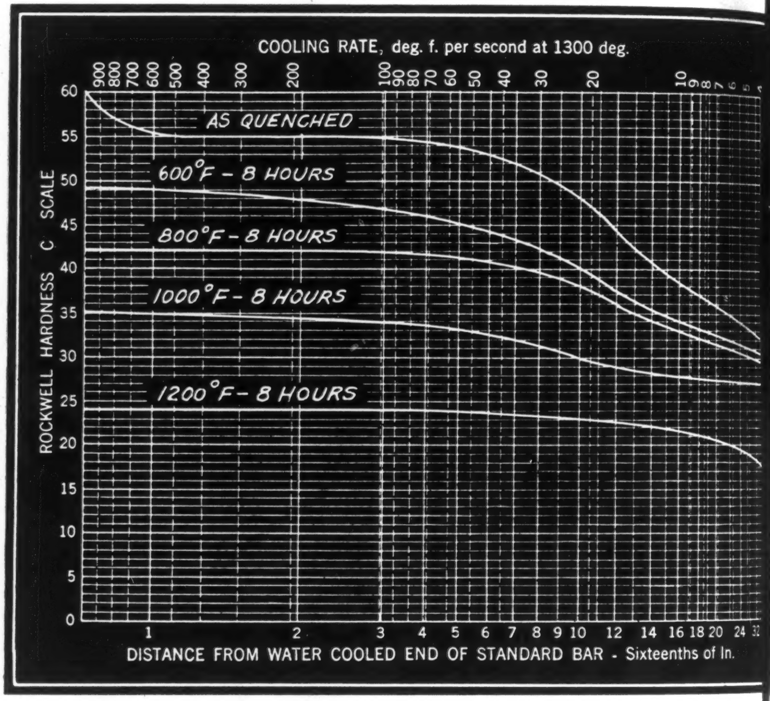


Fig. 3—Curves show effect of tempering on end-quench test pieces of SAE 4140. Quenching temperature was 1550 degrees Fahr.

In order to clarify the preceding discussion, the following example is outlined: A 2-inch diameter section of SAE 4140 has been quenched in still oil and tempered at 800 degrees Fahr. What will be the hardness at the mid-radius of the section? The first step is to ascertain the cooling rate of the mid-radius of a 2-inch diameter section quenched in still oil. By referring to *Fig.* 4, it is observed that the cooling rate is 24 degrees Fahr. per second. Then, referring to *Fig.* 3 and the curve marked "800° F.", it will be apparent that the predicted hardness at the mid-radius of a 2-inch diameter section.

TABLE III

Predicted and Actual Hardnesses for SAE-4140

		1-in. Round			2-in. Round			3-in. Round		
		S	MR	C	S	MR	C	S	MR	C
600 F. Draw	J	44	44.5	44.5	44.5	40	37	42	35	33
600 F. Draw	A	48	49	49	46	40	37	43	36	35
800 F. Draw	J	44	43.5	43	44	39	37	41.5	35	33.5
800 F. Draw	A	44	44	43	44	39	37	43	35	35
1000 F. Draw	J	34	33	33	33	30	29	31	27	27
1000 F. Draw	A	36	35	35	35	30	29	33	28	27
1200 F. Draw	J	24.5	24	24	24.5	22	21	23	19.5	19
1200 F. Draw	A	25	25	25	23	21.5	20	23	21	20

Legend: J—predicted value; A—actual value; S—surface; MR—mid-radius; C—center.

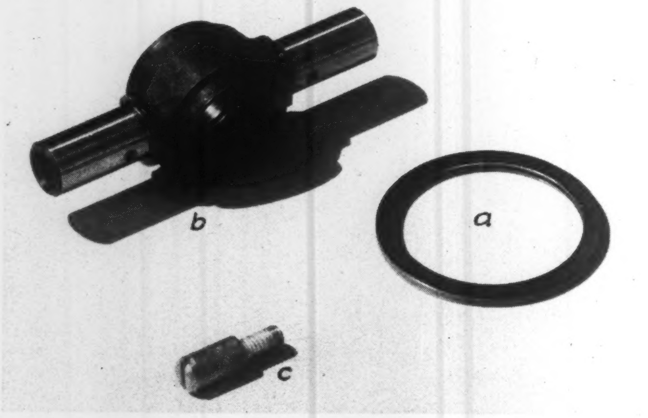


Fig. 2—Use of alternatives for spacer (a) and trunion (b) saves 16 pounds of chromium per 100 pounds of steel

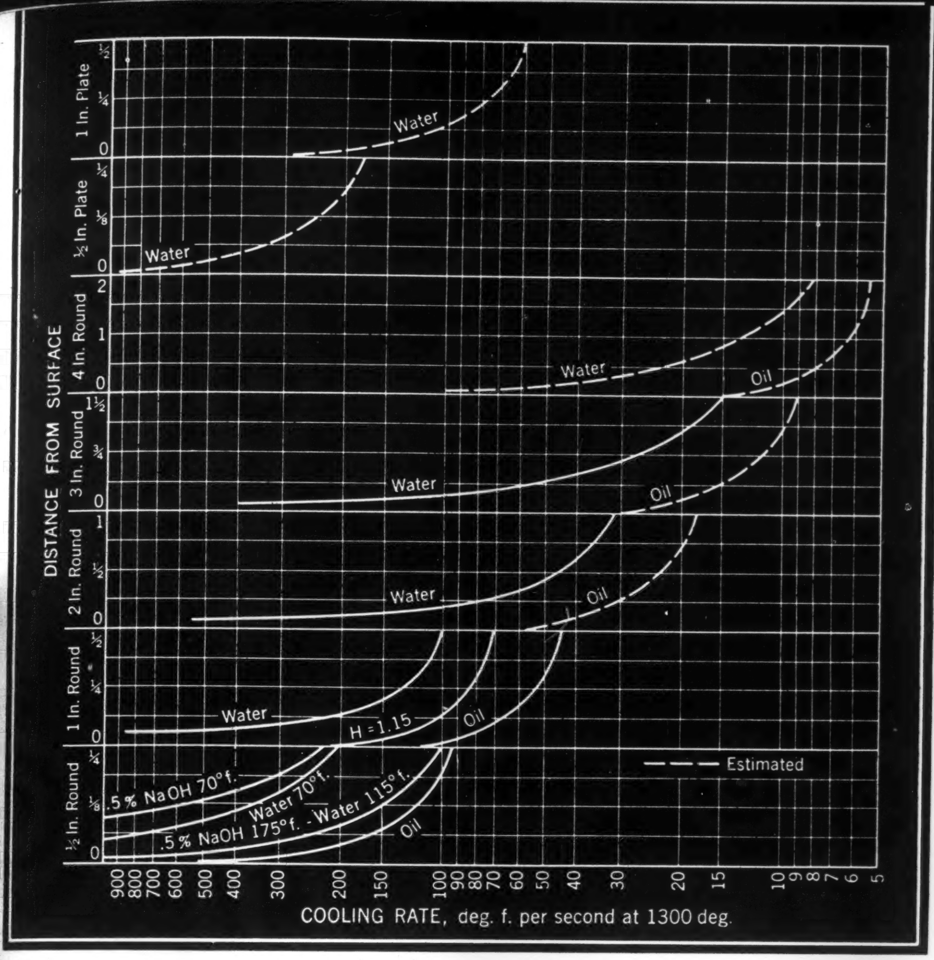


Fig. 4—SAE hardenability chart shows cooling rates between center and surface of various materials, is used to predict hardness at any section

Table IV

Predicted and Actual Physical Properties for Quenched and Tempered SAE-4140

Treatment	Physical Properties	1-inch round Center Predicted	1-inch round Center Actual	2-inch round Mid-Rad. Predicted	2-inch round Mid-Rad. Actual	3-inch round Mid-Rad. Predicted	3-inch round Mid-Rad. Actual	3-inch round Center Predicted	3-inch round Center Actual
800 F. Draw 8 Hours	Rockwell C	43	43	39	39	35	35	33.5	35
	Tens. Str.	204,000	205,300	187,000	169,250	165,000	159,300	160,000	153,500
	Yield Point	188,600	190,030	169,000	159,000	145,000	129,750	139,000	132,800
	Elong., %	13	11.5	14	14.5	16	15	17	15
	Red. Area, %	50	51.2	52	53	52	51.9	53	50
1200 F. Draw 8 Hours	Rockwell C.	24	25	22	21.5	19.5	21	19	20
	Tens. Str.	124,000	117,100	117,000	108,900	112,000	112,950	112,000	110,200
	Yield Point	104,000	100,250	98,000	86,200	92,000	82,250	91,000	84,500
	Elong., %	22	23	23	24	23	23.5	24	24
	Red. Area, %	62	64.7	63	63.5	64	64.7	64	64.2

quenched in still oil and tempered at 800 degrees Fahr., is rockwell C 39. Actually the mid-radius hardness was rockwell C 39 as is shown in Table III.

It is possible to go further than predicting only the hardness of any section. Baeyertz and Janitzky have established that fully-hardened steels of the same rockwell hardness have the same physical properties. This criterion is shown graphically in *Fig.* 5.

Therefore it is possible to go back to the example of a 2-inch diameter section quenched in still oil and tempered at 800 degrees Fahr., and predict its physical properties at the mid-radius of the section. The predicted mid-radius hardness was rockwell C 39. By use of *Fig.* 5 the predicted physical properties are:

Tensile strength	187,000 psi
Yield point	169,000 psi
Elong. in 2 inches	14%
Red. of area	52%

Table IV shows a comparison between predicted physical properties and actual physical properties for quenched and tempered SAE 4140. Although there is a slight discrepancy in these values, all are within engineering limits.

Method Widely Applicable

Because it is generally well-known, SAE 4140 was chosen to describe this method of using the end-quench test. However, the method is universal with respect to steels that can be fully hardened and was checked with various analyses including SAE 3135, Modified 1050, NE 8744, NE 8749, NE 8750, NE 9442, and NE 9445.

Using NE 8744 quenched from 1525 and drawn at 1000 degrees Fahr. for 5 hours, predicted and actual values were, respectively: Tensile strength 165,000 and 162,550 pounds per square inch, yield point 145,000 and 131,250 pounds per square inch, per cent elongation 17 and 15.

A similar comparison with NE 9442 quenched from 1550 and tempered at 1200 degrees Fahr. for 5 hours gave the following predicted and actual values: Tensile strength 125,000 and 124,750 pounds per square inch, yield point 107,000 and 107,000 pounds per square inch, per cent elongation 20 and 22.

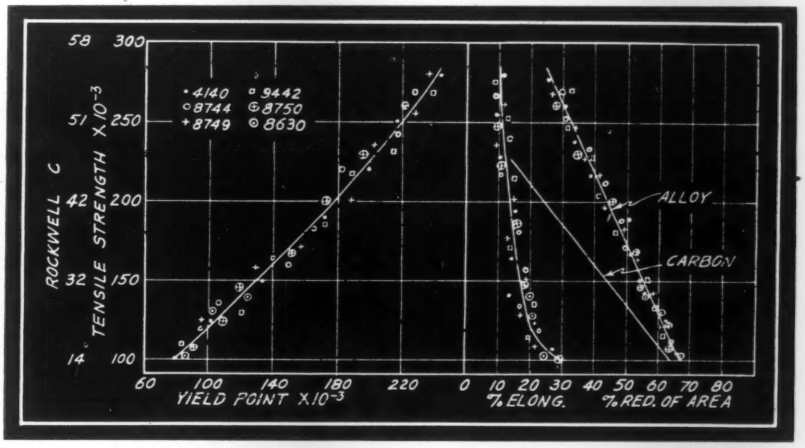
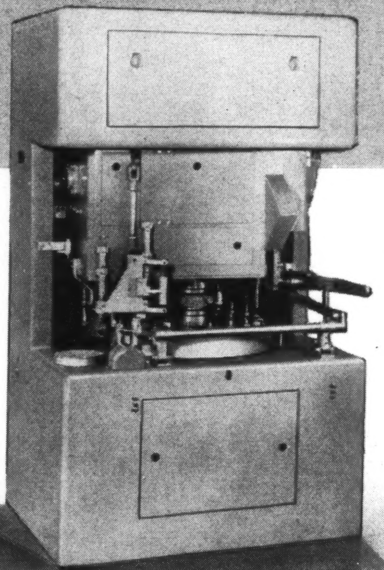


Fig. 5—Chart shows that fully hardened steels of the same rockwell hardness have the same physical properties

Left—Matthews machine for printing color bands, insignia and other data on shell cases has gravity feed input chute. Cradle rolls for holding the piece during the printing operation are multiple-stage. Part being marked is picked up by one cradle roll, advanced to the printing stage, printed and then deposited on a gravity takeaway chute. Cylindrical printing plate uses synthetic rubber type



Left—Both utilitari nd appearance facto ere considered by Cons ted Packaging Machin rp. engineers in design this new machine for ing powder fill and wat oof- ing threaded eleme for ammunition comp nts. Drives are complet en- closed

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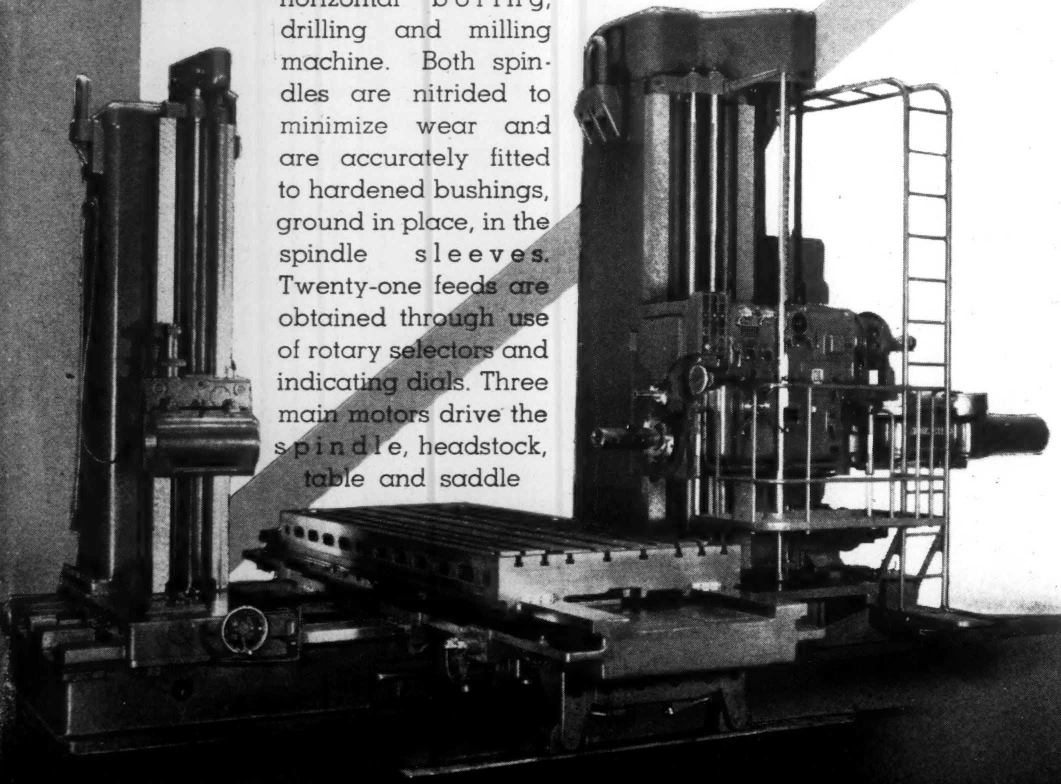
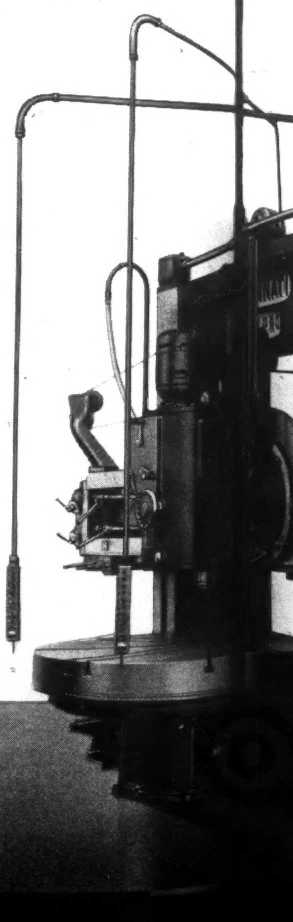
(For new machine li , see pag

Left—New recorder has been designed by Michigan Tool Co. for use with sine-line lead and involute checkers, making permanent chart records of involute tooth forms and leads. The machine utilizes electrical synchronous devices, one being located in the base of the measuring mechanism and the other in the machine. A hinged, plastic cover is provided over the chart roll and recording pen. Serrated bar below the edge of the cover permit tearing off complete charts

Below—Two spindles, each with its own range of speeds, are provided for the Giddings and Lewis horizontal boring, drilling and milling machine. Both spindles are nitrided to minimize wear and are accurately fitted to hardened bushings, ground in place, in the spindle sleeves. Twenty-one feeds are obtained through use of rotary selectors and indicating dials. Three main motors drive the spindle, headstock, table and saddle





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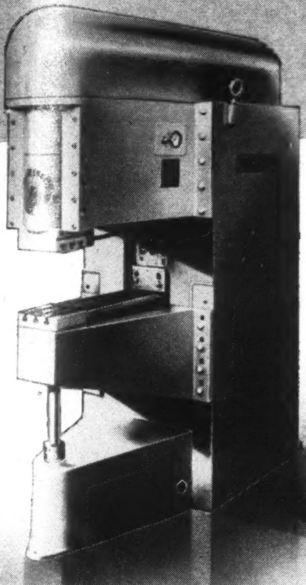
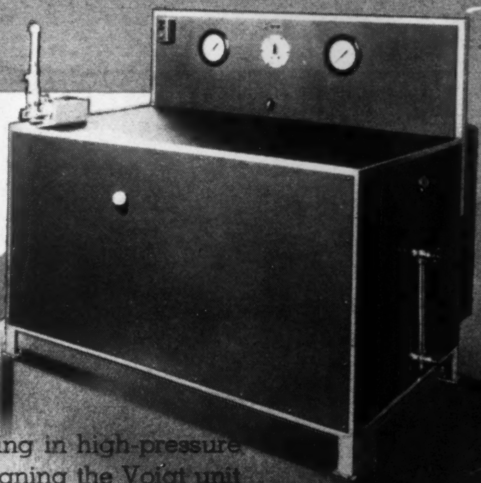
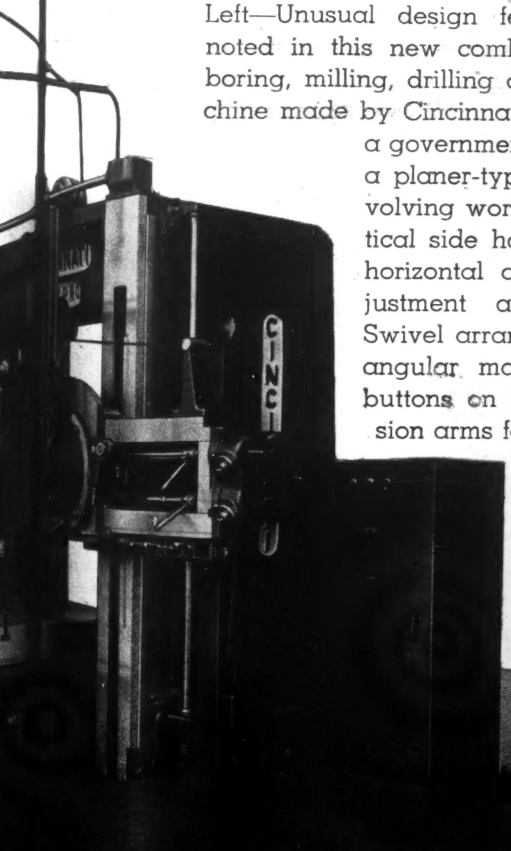


Left—A combination of castings and reinforced plates provides the new Progressive resistance welder with maximum rigidity. Welding heads have long box-type gibs with full adjustment for wear. T-slot platens facilitate mounting of fixtures and dies. Knees of the machine are vertically adjustable to permit setting for various throat openings. Double cooling-water manifolds are located in base of the machine



Above—A 20 per cent saving in high-pressure fittings was effected in designing the Voigt unit for testing aircraft hydraulic devices through the use of a simplified circulating system and unit for instantly controlling pressures over a range up to 10,000 pounds per square inch. Unusually large circulating system, over 30 gallons per minute under pressure, permits testing up to 20 units simultaneously

Right—A plastic housing for a new quarter-inch drill made by the Independent Pneumatic Tool Co. serves as a protective shell, the bearings, gears, stator, centerplate and other parts being supported and held in close alignment by an inner metal skeleton frame. The plastic field case slides over the frame and is held in keyed position against the metal centerplate. Grip handle fits over the end of the frame and is fastened with screws



Left—Unusual design features will be noted in this new combination vertical boring, milling, drilling and turning machine made by Cincinnati Planer Co. for a government arsenal. It has a planer-type cross rail, revolving work table and vertical side housings for both horizontal and vertical adjustment and operation. Swivel arrangement permits angular machining. Pushbuttons on swinging extension arms facilitate control

Below—Twin hydraulic grader-blade control for the Drott clam-type shovel is of nonvented design, air space in the oil supply tank above the oil level plug being used for ram piston rod differential. Hydraulic pumps, designed with heavy-duty bearings and bronze thrust plates, are hydraulically self-balancing. Gear speed-reducing units are used for the power takeoffs

MACHINE *Editorial* DESIGN

"Hats Off" to the Aircraft Industry!

AIRCRAFT production—the one phase of the war in which the United Nations are rapidly outstripping the Axis—stands out as a monument to the progressiveness of American airplane manufacturers. With current production hitting around 7000 planes a month and with new factories such as the Willow Run bomber plant finally getting under way, President Roosevelt's suggested 120,000 planes during 1943—or the equivalent in fighting power—may well be reached.

Such gigantic strides in production have not been made through individual efforts on the part of either new or old companies in the aircraft field, nor through competition between these concerns. In few industries has a closer spirit of co-operation been evident, particularly with regard to the interchange of patents and manufacturing techniques.

It is significant that the aircraft industry now is making an even greater jump ahead—a move that might well be given consideration by other branches of the war industry not as closely knit. Formation of a National Aircraft War Production Council has recently been announced which has as its primary objectives the further expediting of the nation's vastly increased aircraft production and the co-ordination of the facilities of the industry in the service of the Army, Navy and War Production Board.

Combined in the new council will be the separate organizations previously set up on the East and West Coasts, thus bringing into closer collaboration the entire industry. National offices are being established in Washington for close liaison with the war agencies.

Formation of the council, apart from the effect it undoubtedly will have on production, may go far toward ironing out the difficulties confronting the men immediately behind the front lines in servicing the many different types of planes now in action. Co-ordination of the design, development, standardization and simplification program would mean that more planes will be in first-class flying condition at any one time than could be achieved by other means. The new council will have, as would a national council formed within any other industrial group, the power to see that such factors are viewed in their proper relation to the industry's program as a whole.

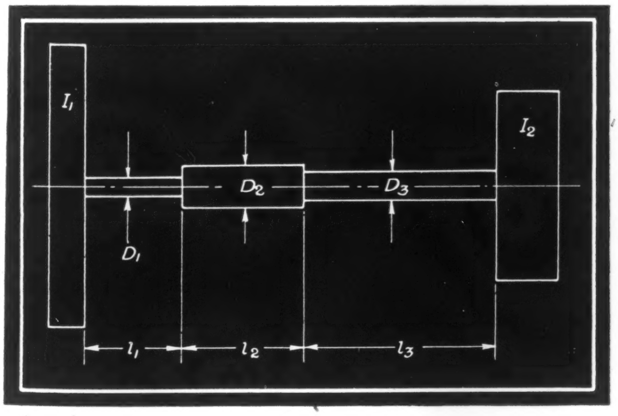
L. E. Jermy

Calculating Natural Frequencies of Torsional Vibration

IN THE design of rotational assemblies subject to torsional vibration, control of natural frequency of free vibration often involves a series of trial and error calculations until the correct proportions are found. To expedite the work of solving such problems the chart*, Page 120, has been prepared. It is applicable to any torsional system which can be reduced to a simple equivalent system consisting of two masses connected by an elastic shaft of negligible mass. Natural frequency of free torsional vibration of such a system is given by the well-known equation:

$$f=\frac{1}{2\pi}\sqrt{k\left(\frac{1}{I_1}+\frac{1}{I_2}\right)} \qquad (1)$$

where f = natural frequency, vibrations per second; k = shaft stiffness constant, inch-pounds per radian; I = mass moment of inertia, pounds-inches-seconds squared ($I = Wr^2/g$); r = radius of gyration, inches; W = weight of rotational mass, pounds; g = acceleration due to gravity = 386 inches per second per second.



The chart, Page 120, solves Equation 1.

Stiffness of a shaft is given by the equation

$$k=\frac{\pi}{32}\,\frac{(D^4-d^4)G}{l} \qquad (2)$$

where D = outside diameter of shaft, inches; d = inside diameter of shaft if hollow, inches; l = length of shaft, inches; G = shear modulus of elasticity, pounds per square inch, = 11.8 x 10^6 for steel.

For a stepped shaft (see sketch) the stiffness constant of the entire length is given by the equation:

$$k=\frac{\dfrac{\pi G}{32}}{\dfrac{l_1}{D_1^4-d_1^4}+\dfrac{l_2}{D_2^4-d_2^4}+\dfrac{l_3}{D_3^4-d_3^4}+\text{etc.}} \qquad (3)$$

As a rule the preliminary design is worked out and the parts proportioned to meet the working loads. Natural frequency is then checked from the chart, using calculated values of I_1, I_2 and k. If this value lies within a speed range likely to cause serious vibration it must be modified by changing one or more of the controlling factors I_1, I_2 and k.

EXAMPLE: Preliminary design leads to the following values: I_1 = 400 lb-in-sec^2, I_2 = 680 lb-in-sec^2 and k = 20,000,000 in-lb per radian. Because the values of I_1 and I_2 are close to the lower ends of the scales in this case, greater accuracy will be obtained if all values are multiplied by 10. This may be done without necessitating any correction to the frequency f, as indicated by Equation 1. Connect I_1 = 4000 and I_2 = 6800 (see key diagram at lower left of chart) and from their intersection with the horizontal line at (1) follow a perpendicular to meet the curve at (2). Then follow a horizontal to the vertical line at (3). Join the point (3) with k = 200,000,000 = 2 x 10^8 and extend to the f-scale where the value f = 45 cycles per second is read.

If the value of f happens to be close to the working speed, leading to a critical condition, the necessary modifications may also be found from the chart. Thus assuming the value of f must be not less than, say, 50 cycles per second, connect this point with the point (3) previously found. The new value of k to give this natural frequency is located where this line crosses the k-scale, and may be used as the basis of a redesign of the shafting, using Equation 2 or 3.

In case a change in shafting design cannot be accommodated, modification of I_1 or I_2 is necessary. To find suitable new values connect f = 50 with k = 2 x 10^8 and extend to a new point on the vertical scale (3). By working backward find a new point on the horizontal scale (1). A series of lines may be drawn through this point, their intersections with the I_1 and I_2 scales giving corresponding values which will satisfy the conditions of the problem.

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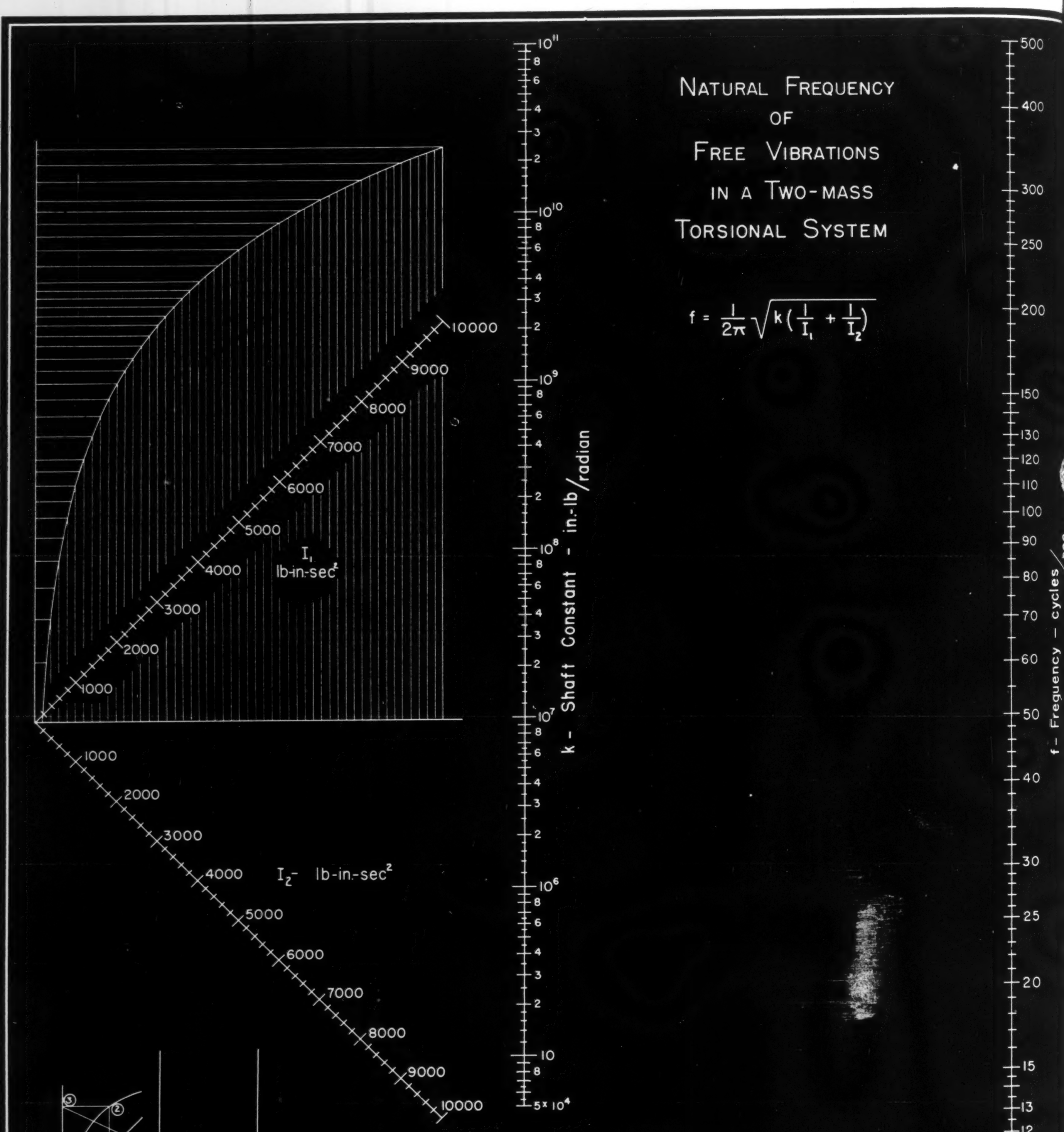
*This chart has been prepared by Professor R. D. Douglass, Massachusetts Institute of Technology, and Lieutenant J. M. Dunford, U.S.N.

NATURAL FREQUENCY OF FREE VIBRATIONS IN A TWO-MASS TORSIONAL SYSTEM

$$f = \frac{1}{2\pi}\sqrt{k\left(\frac{1}{I_1} + \frac{1}{I_2}\right)}$$



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". . . method shortens solution"

To the Editor:

The article "How Acceleration Analysis Can Be Improved", by A. S. Hall and E. S. Ault, which appeared in the February and March issues of MACHINE DESIGN, contained an admirable presentation of the theory and application of Coriolis' law. Courses and textbooks on kinematics too often have stopped short of an adequate treatment of acceleration. Even where this important topic was included, a good working knowledge of the Coriolis component was not always realized. The absence of such knowledge renders the solution of acceleration problems in machines a hazardous activity. The designing engineer who finds it necessary to do a job of self-education on this topic, or to review it, will find the article enlightening.

Engineers are queer people. They get little satisfaction out of a mathematical development, however rigorous, unless it has a counterpart in physical performance. When Professors Ault and Hall conjure up the revolving skating rink to illustrate the physical significance of the Coriolis component they strike a high point in exposition and reveal that they have had long experience in dealing with the inquiring mind.

The "equivalent mechanism" method can often be used in acceleration problems to shorten the work markedly, sometimes eliminating the Coriolis component entirely. Without naming it, the authors have really used this method in the cases of *Figs.* 7 and 8, (M.D., March 1943, Page 91). In *Fig.* 7 the plane surface of the cam has in effect been moved out to a parallel plane through *B*, while the roller has been reduced to a point at *B*. This gives an equivalent point-plane or slider-plane mechanism. Similarly in *Fig.* 8 the plane surface of link 3 has been moved to a parallel position through *C*, while the curved nose of link 2 has been reduced to a point at its center of curvature *C*, again giving the slider-plane equivalent mechanism. Note that the mechanisms are really equivalent so far as performance in the particular phase is concerned.

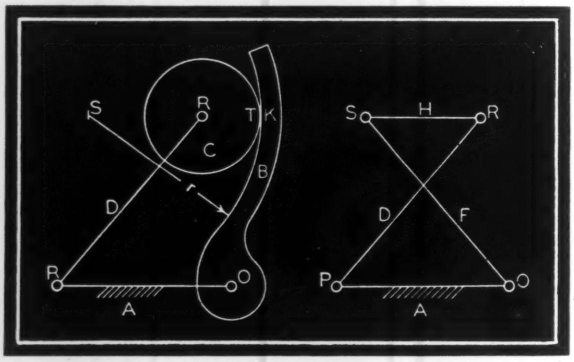

Fig. 1—Acceleration solution for equivalent mechanism, right, is less involved than for actual mechanism, left

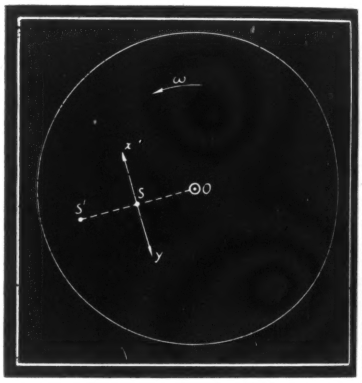

Fig. 2 — Illustrates the experiences of a skater S as affected by his velocity with respect to revolving rink

Consider the mechanism at the left of *Fig.* 1* herewith. A direct solution for acceleration is quite involved, but the equivalent mechanism, given at right, is the crossed four-bar linkage. The solution for the latter is relatively simple. Nearly all mechanisms involving direct-contact transmission can be handled more simply by the use of this equivalent-mechanism method. The writer found it necessary recently to formulate this technique as it relates to cams, and the table* given on Page 124 resulted.

Those acquainted with the phorograph preferably use it when dealing with the Coriolis component. Its advantage lies in the fact that it gives not only the magnitude but the sense in such a simple and direct manner as to make error less probable.

Take the case of the revolving skating rink, *Fig.* 2 herewith. This turntable rink is revolving about axis O at ω radians per second counterclockwise. Let the skater S have the same velocity S_y relative to the ring, that the point of the rink under his feet has relative to the ground. The skater is then moving $2(S_y)$ relative to the ground. The phorograph of the skater, on the rink, is the point on the rink that has the skater's velocity. (This defines the meaning of the term phorograph.) Obviously, this point is S' such that $OS' = 2(OS)$. S' is the phorograph of S on the rink. The direction of the Coriolis component is always from the phorograph to the point itself, in this case from S' to S. The magnitude of the component is

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*From "*Applied Kinematics*", 2nd edition, D. Van Nostrand Co. Inc.

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1	curved	rotation	curved	rotation	quadric
2	curved	rotation	curved	translation	slider-crank
3	curved	rotation	plane	rotation	slider-plane
4	curved	rotation	plane	translation	slider-plane
5	plane	rotation	curved	rotation	slider-plane
6	plane	rotation	curved	translation	slider-plane
7	curved	translation	curved	translation	double-slider
8	curved	translation	plane	rotation	slider-plane
9	curved	translation	plane	translation	slider-plane
10	plane	translation	curved	translation	slider-plane

equal to $2(S'S)\omega^2$.

Consider the case where the skater moves in direction S_x relative to the rink at such a rate that he becomes stationary relative to the ground. Now his phorograph S' is at O, because O is the only point on the rink that has no motion relative to the ground. The direction of the Coriolis component is O to S, and its magnitude is $2(OS)\omega^2$.

Next suppose that the skater stops on the ice and rides with it as the rink revolves. His phorograph S' is now at S. There is no Coriolis component since $S'S$ is zero.

—J. Harland Billings
Drexel Institute of Technology

". . . helps our understanding"

To the Editor:

The members of our organization were greatly impressed with the articles on acceleration analysis by Hall and Ault that appeared in the February and March issues of Machine Design. We certainly agree with the authors that there is not sufficient recognition of the Coriolis Law.

It is unquestionably a difficult principle to grasp. While the component can easily be demonstrated mathematically, the physical concept is not at all obvious. For this reason we enjoyed the example of the skating rink given in *Fig*. 5. Everyone knows from instinct that this effect occurs, greatly helping our understanding.

An interesting example encountered some time ago is shown in the schematic drawing on Page 126 of what we call a "strip curler." The basic requirement of this mechanism was that the "shear lever", once each revolution, travel with the "curling disk". How this was accomplished is obvious from the drawing. Now this shear lever carried a considerable weight of parts and the whole machine was required to operate at rather high speed so that the acceleration forces were of paramount importance. Analysis was made using Angus' phorograph which ignores the Coriolis component. If a check had not been made by constructing a velocity diagram and comparing the slope of the velocity curve with the acceleration, a great deal of trouble would have been experienced. As it was, a serious discrepancy was found which we were unable to explain. We took the practical course and found the acceleration from the velocity curve since it gave the higher figure.

So far as the writer knows, the use of the complex variable to represent vectors in velocity and acceleration problems is novel. It certainly simplifies the mathe

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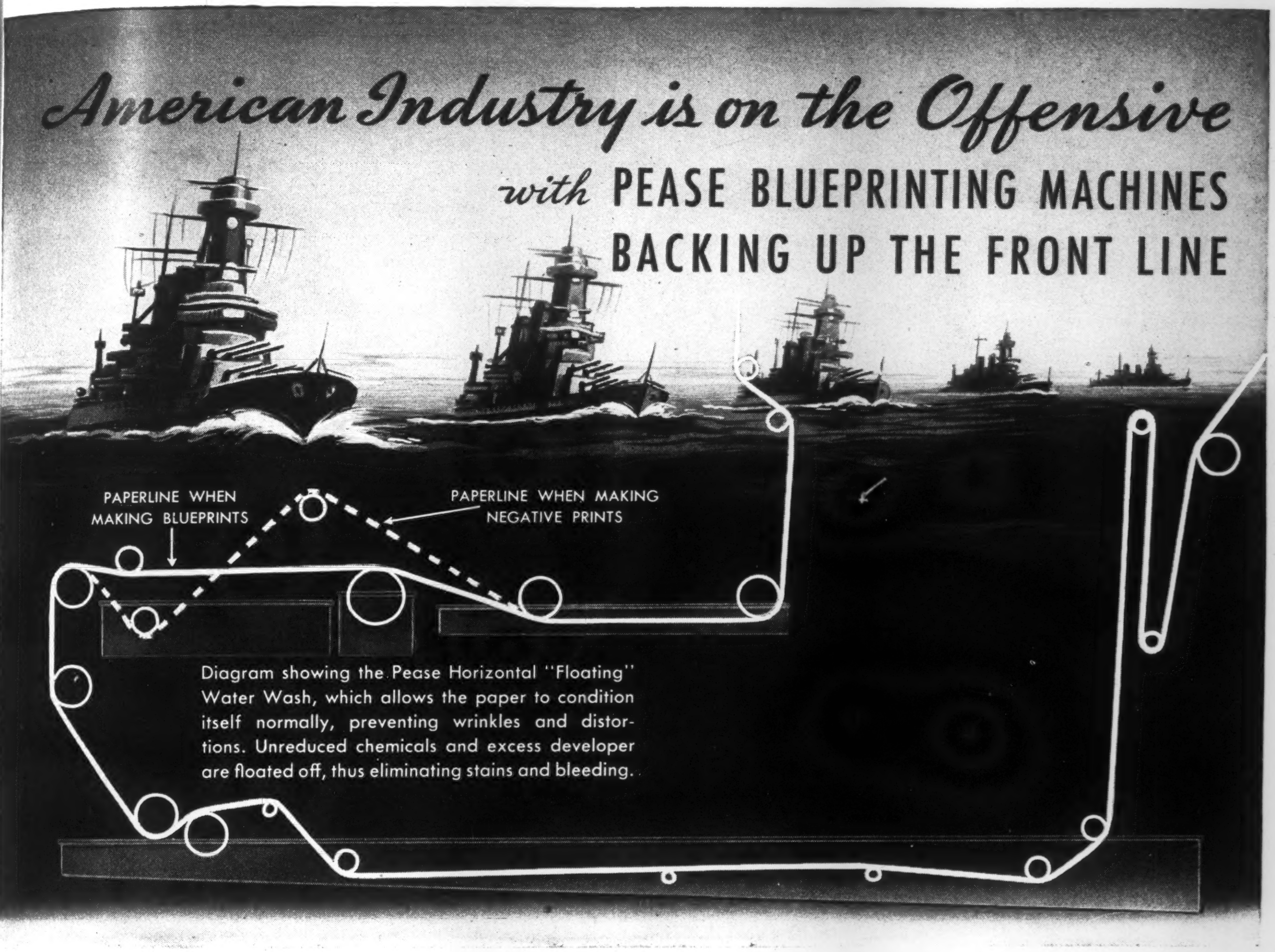
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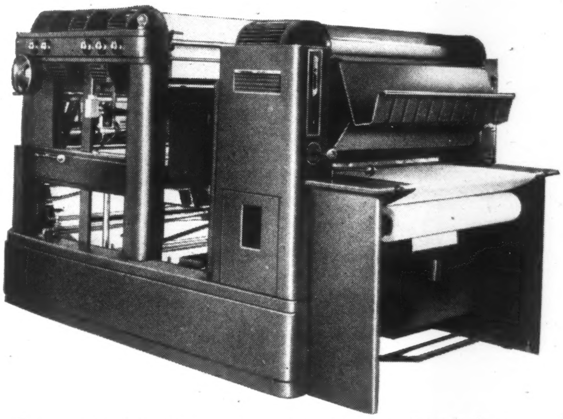

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THE ANSWER MAY BE

Felt

● When the pressure is on for production of a vitally needed war product . . . and a shortage of conventional materials blocks progress . . . FELT in one of the many forms developed by Western may provide the answer.

Particularly is this true where the job demands insulation, resiliency, sound deadening, flexibility, compressibility, resistance to water and many other properties of rubber.

On any problem involving the use of felt . . . or the substitution of this material for another . . . draw freely on the extensive background of Western Felt's 42 years' experience in fabricating felt to close specifications.

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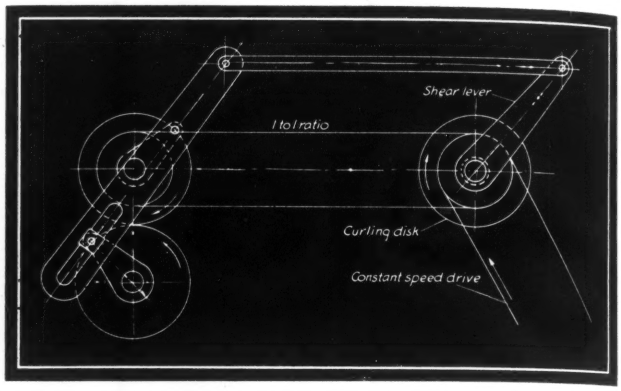
The Acadia Synthetic Division of Western Felt are processors of Plastics (Sheets, Extrusions, Tubings, Molded Parts) and Synthetic Rubber. Write for information.

WESTERN Felt
Largest Independent Manufacturers and Cutters of Hair, Wool and Jute Felts



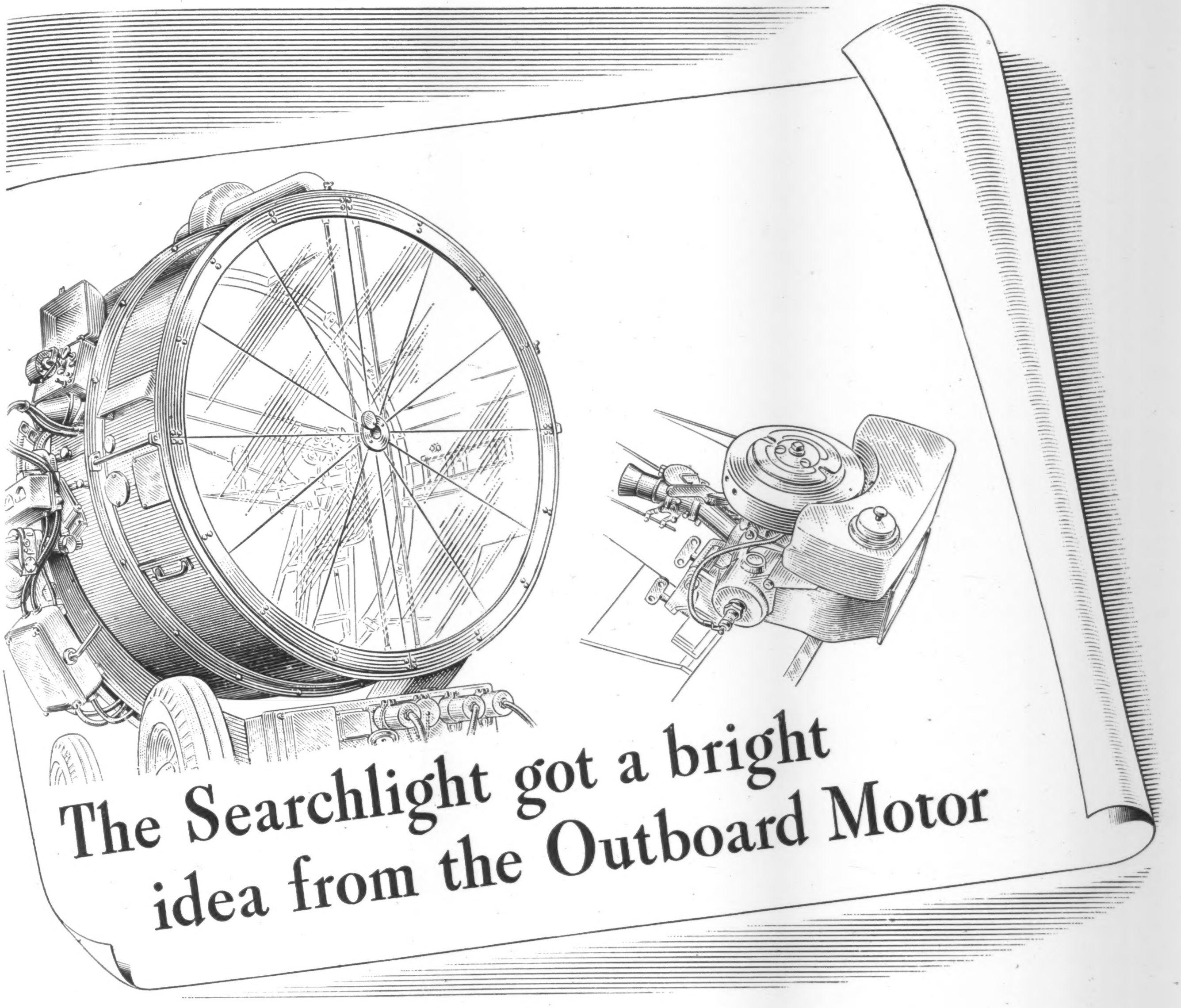
matics and we feel that the authors are due a great deal of credit for this presentation. It would seem that the method could be developed in many other problems and we would recommend that the writers make that attempt and present the results of their work.

It is of some interest to note that there are at least five methods of solving for the Coriolis component:

1. Average acceleration is first found by obtaining the vector difference in velocities over an interval of time, then dividing by the time. The instantaneous acceleration is then obtained by proceeding to the limit. The velocities are found in terms of the radius of the path of curvature. The velocity at the end of the time interval is expressed in terms of the new point on the body with which the moving point is coincident, and the velocity of the new point with regard to the first coincident point. This method will be found in Ham and Crane's "Mechanics of Machinery" (McGraw-Hill Book Co. Inc.), also in Dent and Harper's "Kinematics and Kinetics" (John Wiley & Sons Inc.).
2. Total acceleration of the moving point is broken up into its seven elements, three due to the motion of the particle along its path and four due to the motion of the path itself. This gives the acceleration directly. These seven elements then may be combined to obtain the usual expression of the Coriolis law. This may be found in Seeley and Ensign's "Analytical Mechanics for Engineers" (John Wiley & Sons Inc.).
3. Position of the moving point and the point coincident with it are first located by means of coordinate axes fixed on the moving body. The projections of these locating coordinates on a second set of axes fixed in space are then found. This gives the position of the moving point and the coincident point in terms of the angular and space position of the moving axes and their coordinates. By differentiating twice, the projections of the acceleration on the fixed axes are then found. This method is presented in Timoshenko and Young's "Engineering Mechanics" (McGraw-Hill Book Co. Inc.).
4. A method similar to the above also differentiates the coordinates of the two points referred to axes fixed in space, but locates through the center of curvature of the path of the moving point on the moving body.
5. To the above is now added the method of Hall and Ault.

It is an interesting and comforting reflection to realize that in the sciences it matters not what path we choose to follow to attain our objective, we always arrive at the same conclusion. This we all know and accept, but nevertheless one cannot help but be impressed by such an outstanding example.

—R. E. Orton
Acme Steel Co.



The Searchlight got a bright idea from the Outboard Motor

OFFHAND, you wouldn't think there was anything in an outboard motor that could make the going easier for an anti-aircraft searchlight. In designing "outboards," the chief requirements are small space and high load capacity. So builders of outboard motors chose the Torrington Needle Bearing—it's unusually compact for an anti-friction bearing, and noted for high load capacity.

In the anti-aircraft searchlight, size of parts is a secondary consideration, so long as the equipment is transportable. Yet searchlight designers, ever striving for quicker response in locating enemy aircraft, welcomed the Needle Bearing as eagerly as outboard motor manufacturers. And not merely for its high load capacity, which helps prevent overloading and breakdowns, or low coefficient of friction, permitting crews to swing a searchlight's beam into immediate action at the first warning signal.

There's the Needle Bearing's reliable performance, for example—an invaluable feature when enemy planes are overhead—its effective system of lubrication, which enables the bearing to run for long periods without *any* attention at all—and its ready availability, helping to provide our Armed Forces with enough and on time.

THERE MAY BE AN IDEA HERE FOR YOU, TOO, in planning your product's post-war designs. Savings in weight, compact design, infrequent lubrication, dependable operation—these are features your regular customers most likely will insist upon after the war, and the Needle Bearing has every one of them, as well as low cost and ease of installation. Now is the time to "iron out," with the help of Torrington engineers, the details in adapting the Needle Bearing to your particular applications. For preliminary information on sizes, ratings, and typical applications, send for Catalog No. 109.

NEEDLE BEARINGS FOR ALL PURPOSES

LOOSE ROLLERS are produced in a range of sizes for assembly into low-cost, high-capacity anti-friction bearing units. They are particularly adaptable to applications where volume permits installation of the necessary equipment.

NEEDLE BEARINGS are complete, self-contained units consisting of a full complement of rollers and a thin, hardened outer race. They offer the advantages of small size, low cost, high capacity—and are easily, quickly installed.

QUILL BEARINGS consist of a full complement of rollers and a relatively heavy hardened outer race. They are furnished with or without inner races. Quill Bearings are adaptable to heavier load requirements than Needle Bearings.

THE TORRINGTON COMPANY
Established 1866 • Torrington, Connecticut, U. S. A.
Makers of Needle Bearings and Needle Bearing Rollers

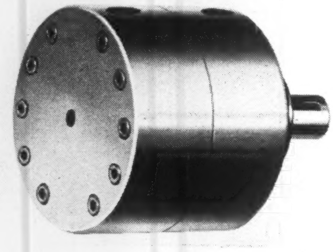
New York Boston Philadelphia
Detroit Cleveland Seattle
South Bend San Francisco Chicago
Los Angeles Toronto London, England

LET'S GO! U.S.A. KEEP 'EM FLYING!

TORRINGTON NEEDLE BEARINGS

New PARTS AND MATERIALS

Hydraulic Dual-Vane Pumps

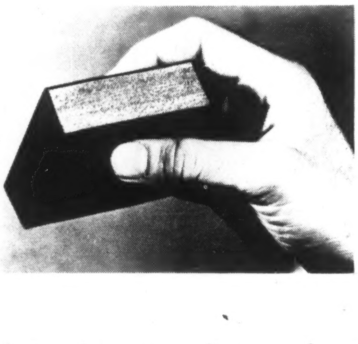


THREE new constant delivery, hydraulic vane type pumps have been designed by Hydra-Motive Division, 723 East Milwaukee avenue, Detroit, for high-pressure operation with high operating efficiencies. The new pumps are of dual vane design, permitting operation without overheating and enabling them to withstand line surge without damage. Instead of a single vane in each vane slot two vanes are used, each ground with a bevel so that oil under full operating pressure can reach the outward edge of each pair of vanes. This back or counterbalancing pressure can be varied by changing the angle at which the vanes are ground so that vanes are held against the stator with only the necessary amount of pressure to effect an adequate seal. Capacities of the pumps range from 2½ to 60 gallons per minute. Incorporated also in these pumps is the new "compound pumping" feature which increases capacity by as much as 30 per cent without increasing overall size of the housing. It consists essentially of employing the ends of the vanes nearest the shaft to function as a piston-type pump. On the intake cycle, the vanes pick up oil from an intake port and trap it in the slot, and on the outlet or pressure portion of the cycle the oil is forced out of the slot into an outlet port which connects with the main outlet. This occurs twice during each revolution of the rotor and at diametrically opposite sides so that it is entirely balanced. The three pumps are available with foot mounting, while the two smaller pumps can be had with motor adaptor mounting. Moving parts are of hardened and ground alloy steel, and housing is of a special leakproof alloy. Overall diameter and lengths (including shaft) are respectively 3 x 6⅞; 4¾ x 8; and 6¾ x 13 inches.

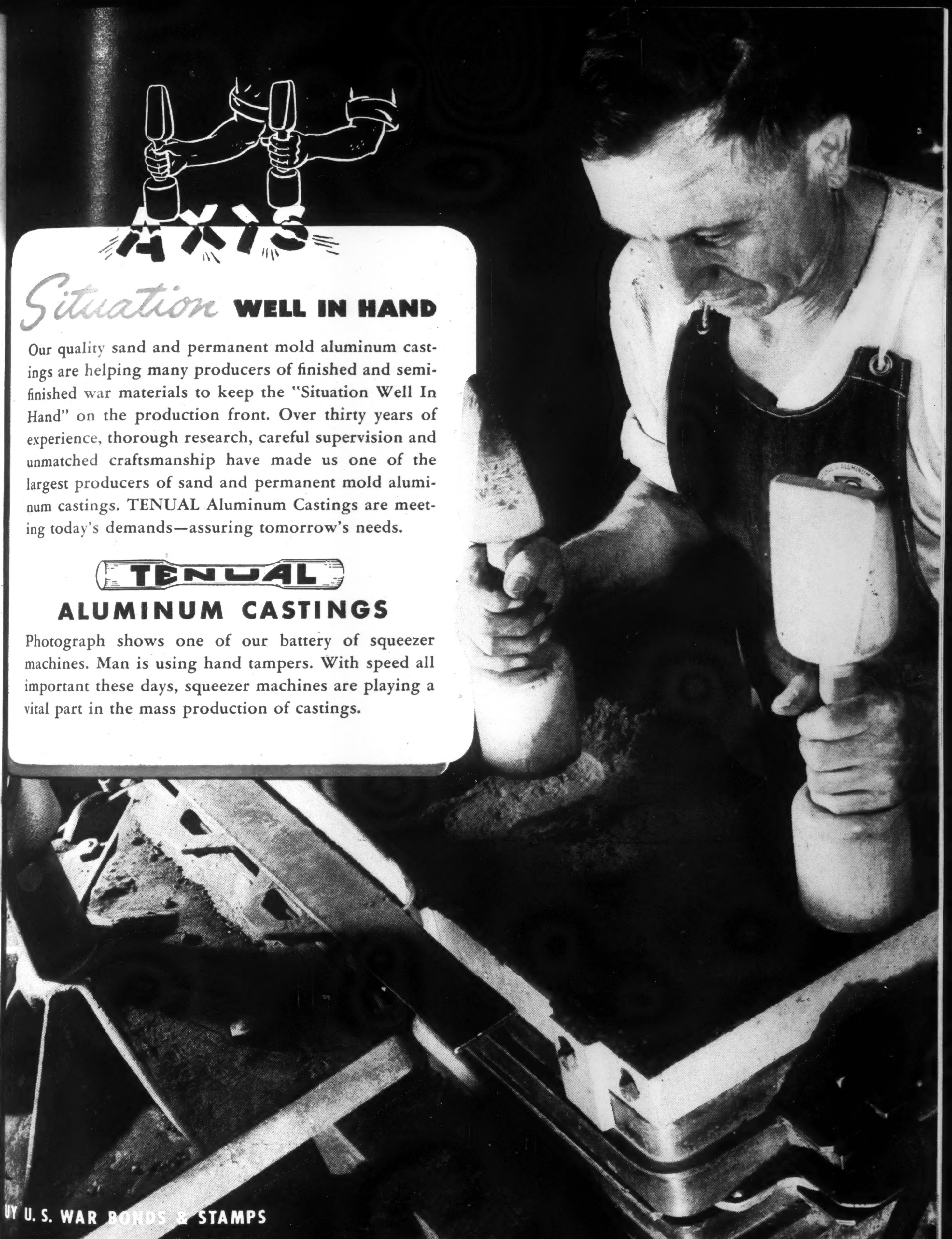
Reducer Type Transmission

BUILT by Reeves Pulley Co., Columbus, Ind., the new reducer type transmission consists of the company's standard variable speed transmission with built-in speed reducer. Developed to meet requirements for accurate speed control and speed reduction combined in a compact, completely enclosed unit, this drive needs far less mounting space to obtain lower range of speeds. It is available in two types, horizontal and vertical. A wide range of speeds, and capacities from 1 to 7½ horsepower inclusive are obtainable. In various sizes the transmission produces ratios of speed variation from 2:1 to 12:1, and the reduction gears provide ratios up to and including 6.9:1. If completely automatic regulation is desired, this is available by mechanical or hydraulic methods. Speed changes may also be affected by turning a handwheel. In either the horizontal or vertical design, the transmission may be equipped for individual motor drive by use of a motorbase. Mounting is directly above the transmission. Connection between motor and constant speed shaft may be either silent or roller chain and sprockets, multiple V-belts or pinion and gear.

Sponge Rubber Gasket



COVERED with a smooth coating of natural rubber or Ameripol synthetic rubber by the extrusion process, a sponge rubber gasket has been announced by The B. F. Goodrich Co., Akron, O. Used mainly in airplanes and tanks where they are proving their value as a sealing member in severe service, the new type of gasket is expected to find wide use in refrigerators, automobiles and in other applications. The gasket when made with a covering of synthetic rubber with-



Situation **WELL IN HAND**

Our quality sand and permanent mold aluminum castings are helping many producers of finished and semi-finished war materials to keep the "Situation Well In Hand" on the production front. Over thirty years of experience, thorough research, careful supervision and unmatched craftsmanship have made us one of the largest producers of sand and permanent mold aluminum castings. TENUAL Aluminum Castings are meeting today's demands—assuring tomorrow's needs.

TENUAL

ALUMINUM CASTINGS

Photograph shows one of our battery of squeezer machines. Man is using hand tampers. With speed all important these days, squeezer machines are playing a vital part in the mass production of castings.

UY U. S. WAR BONDS & STAMPS

HE NATIONAL BRONZE & ALUMINUM FOUNDRY CO.

CLEVELAND, OHIO

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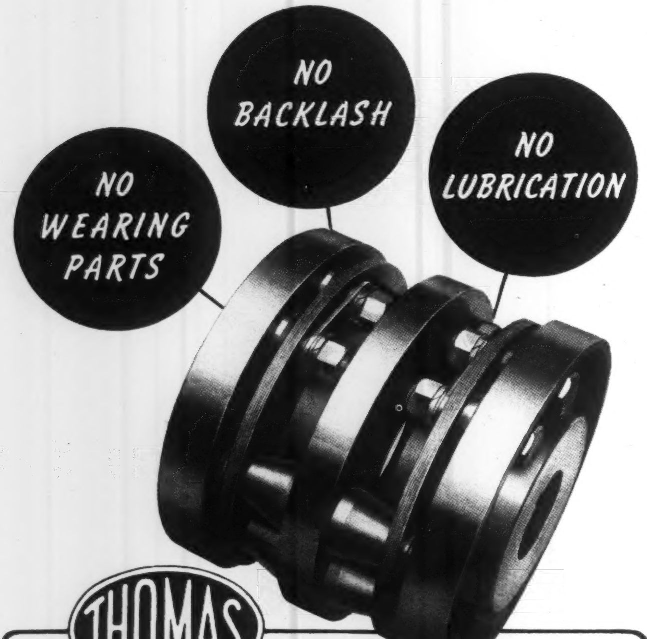
AKERS OF QUALITY SAND AND PERMANENT MOLD ALUMINUM CASTINGS

THOMAS Flexible Couplings



THOMAS

The Only Flexible Coupling With All of These Advantages

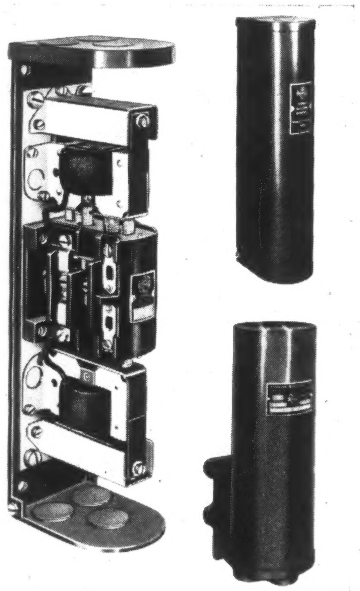
Here is the most outstanding type of flexible coupling in the United Nations' war production industries. Thomas Couplings will last without maintenance as long as the equipment which they connect. They reduce your maintenance costs on both the prime movers and the connected machines—thus time out periods for breakdowns hit a new low, while your sustained production reaches a new high. These long-life qualities have been demonstrated for many years in steel, petroleum, fabrication, and transportation fields. Thomas Couplings not only eliminate all backlash, require no lubrication, and have no wearing parts, but they also have fixed torsional rigidity, and eliminate all end-thrust. Write for a catalog of complete data.

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNA.

stands destructive action of oils and greases, and extremely low temperatures, all of these features making it especially valuable in the refrigeration industry. It also has a much lower permanent set than the tubular type used on refrigerators and automobiles, and is soft and compresses well. In the new process the sponge rubber filler is molded in slab form, slit into strips and fed through a special extruding machine to obtain the smooth covering which varies in thickness according to the requirements. Available in round, square and rectangular shapes, the new gasket is most practical at present in dimensions not smaller than ¼-inch nor larger than 1½-inch. While maximum production length is 12 feet, it can be spliced to any desired length with connecting points hardly detectable. It can be produced with a lip for attachment where necessary.

Magnetic Reversing Switch

MADE as a single unit instead of two separate contactors, the new improved 5-horsepower magnetic reversing switch of Furnas Electric Co., 439 McKee street, Batavia, Ill., permits reversing control of motors by the use of a pushbutton near, or at a distance from switch or motor. It provides a convenient method for operating many types of equipment requiring pilot devices such as limit switches. Compact and small in size, the unit consists of one contact assembly and two magnets to operate movable contacts for "forward" and "reverse". This type of construction eliminates all internal wiring.



Overall size of the switch is 12⅜ x 3¾ x 3 inches. While small in size, the switch is suitable for severe plugging and other heavy duty. Coils can be operated 500 reversals per minute without undue heating. Mechanical life is well over 5 million cycles. Double-break, ⅜-inch diameter silver contacts are used in the switch. Positive mechanical interlocking is achieved by the single unit construction and is obtained by pushrods for the movable contacts, making it impossible for one set of contacts to

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K+E
TRADE MARK

PHOTACT prints take the wear and tear of frequent handling — our originals serve only as lasting records

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Pencil tracings become blurred and smudged with too much handling—or too many runs through the blueprint machine. Even ink tracings can be damaged from frequent use.

Photact *preserves* your originals–whether pencil or ink. By making a Photact of your original you need no longer expose these valuable drawings to the effects of much handling or rough use. Your Photact becomes the "master" for every purpose of reference and reproduction—and your original may be filed away as a permanent record.

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The lines of each Photact have such high opacity, even when made from pencil tracings, that black-line or blueprints made from a Photact "master" are always much more legible than those made from the original.

This high-quality reproduction with sharp contrasts and clearly-defined lines makes Photacts ideal for use in sub-contracting, branch plants—government requirements, etc.

Erasures and changes can be made easily on a Photact.

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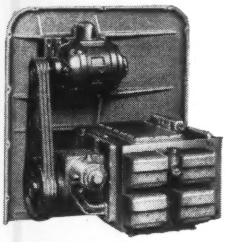
Are You Designing a Machine

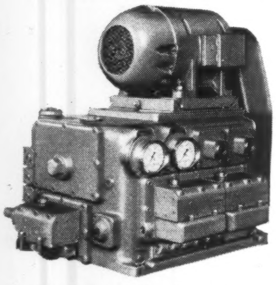
...THAT CAN BE IMPROVED WITH HYDRAULIC UNITS LIKE THESE?

● The Barnes Unit-Type method of securing hydraulics for industrial equipment offers one of the fastest and most efficient hydraulic design services available. Complete circuits are designed and built from Barnes standard hydraulic elements—pumps, valves, etc. These are assembled into compact units simple to install.

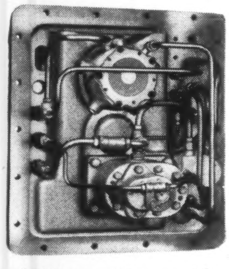
Gain all of the inherent advantages of hydraulic power plus the savings in design and assembly time resulting from this unit-type hydraulic design.



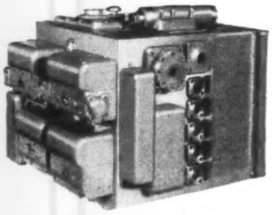
Compact Hydraulic Unit for Rifle Chambering Machine.



Complete Hydraulic Unit for Special Purpose Machine.



Panel Unit complete except for tank which is integral with Machine.



Self-Contained Hydraulic Unit Complete with Pumps, Valves and Tank.

Two Methods Available

Method 1—Barnes Self-Contained Hydraulic Unit can be designed with necessary pumps and valves to complete hydraulic functions of your machine. Oil reservoir is included—providing cylinder space and connecting two pipes to each cylinder constitutes your total hydraulic effort.

Method 2—Use a Barnes Panel Unit—similar to above, except provision must be made in machine for oil reservoir and motor mounting.

BARNES
hydraulics

FREE DATA

40 page booklet contains detail descriptions of Barnes Hydraulic elements and typical installation circuits. Write for your copy today. Ask for Bulletin M.D.543.

John S. Barnes Corporation

DETROIT SALES OFFICE
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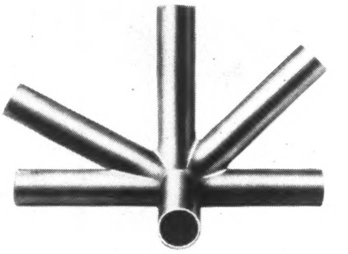
TR-1-1706

MAIN OFFICE
AND FACTORY
ROCKFORD, ILL.

come in as long as the others are closed. The switch is made for either vertical or horizontal mounting, and is finished in machine tool gray.

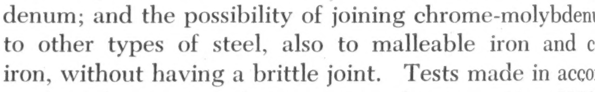
Welding Rod for Chrome-Molybdenum

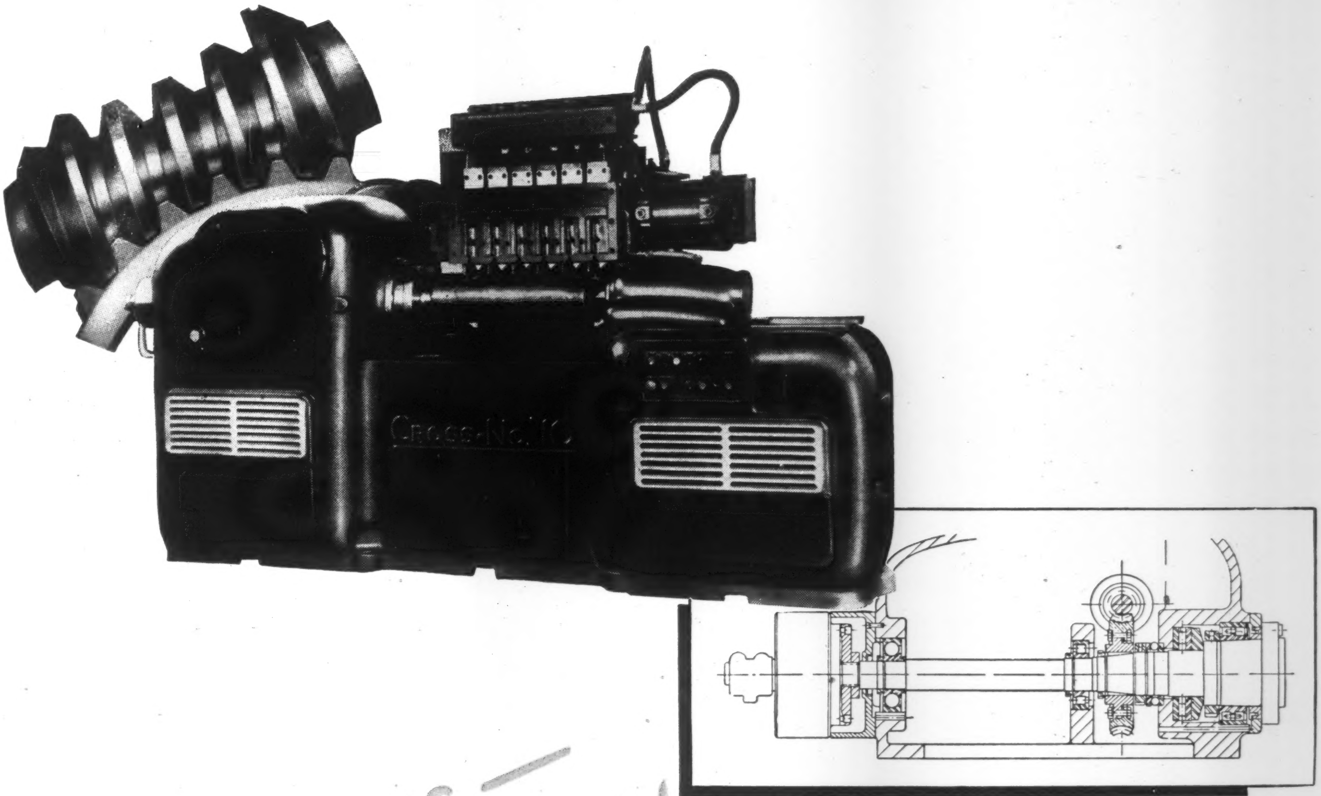
FOR use on chrome-molybdenum steel in aircraft production, the new low-temperature welding process of Eutectic Welding Alloys Co., 40 Worth street, New York, is meeting the increasing demand for faster and more reliable welding procedures. Some of the advantages of the rod are: Low temperature of 1300 degrees; high speed of operation; free flowing properties making it easy to join delicate clusters and assemblies; distortion and overheating completely avoided; dissimilar sections or intricate joints with a large variety of shapes can be joined safely without any ill effects of heat; no change in the structure of the steel which is particularly important when high-carbon steel is used instead of chrome-molybdenum; and the possibility of joining chrome-molybdenum to other types of steel, also to malleable iron and cast iron, without having a brittle joint. Tests made in accordance with Army and Navy Specifications No. 20013B indicate that tensile strength of joints made with Castolin Eutectic Alloy No. 16 is between 10.8 and 35.4 per cent higher than the tensile strength required by the specifications.



Flexible Seamless Metal Hose

SEAMLESS flexible metal hose has been developed by Atlantic Metal Hose Co. Inc., 123 West Sixty-fourth street, New York, for use in connection with machinery to compensate for misalignment and vibration, as well as to provide a flexible medium between moving parts and machinery. Made from a single piece of seamless rigid tubing, making it oil, gas, air and watertight, the flexible hose is available in bronze, steel and monel metal. Uniform wall thickness provides maximum strength for weight of metal. Another feature of the tubing is its bellows construction, permitting it to be tied into a knot without damage. It is available from ⅛-inch to 4-inch inside diameter in various types. For ordinary service at or near atmospheric pressure, Type A is recommended, while braid reinforced or braided and armored hose, Types A-1, A-2 and A-3, are specified according to pres-





Cross-section of headstock of Cross Gear and Machine Company's new 100 hp. shell lathe, showing Cone-Drive gearing for the spindle drive. Notice the liberal use of ball and roller radial and thrust bearings to carry the high loads and horsepowers which this form of gearing can transmit in proportion to its size.

1 Smoothness —
2 Longer carbide tool life
3 Greater shell output

THE THREE go hand in hand. To get all three Cross Gear and Machine Company uses Cone-Drive gearing to drive the spindle of its 100 hp. Shell Lathe.

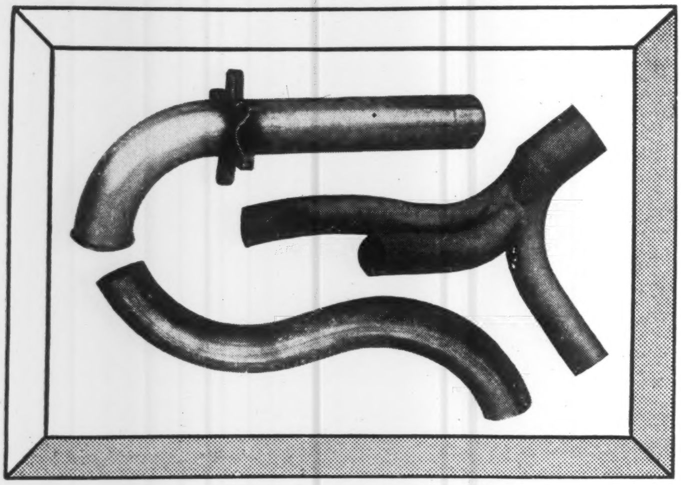
The reason is that the greater number of teeth in contact and the larger individual tooth contact provide greater resistance to wear through reduced unit pressure and also insures maximum smoothness in operation.

That means maximum protection for the multiple carbide tooling, resulting in fewer tool changes and greater overall output—since the machine can be operated at the optimum speed for carbide tools.

For any machine designed for carbide tools, Cone-Drive gearing possesses advantages which are well worth investigating.

Write on your company letterhead for Manual CW41-A (for designers), CW41 (for executives).

CONE-DRIVE DIVISION MICHIGAN TOOL COMPANY
7171 E. McNichols • Detroit, U.S.A



5 reasons why

it's easy to fabricate Welded Stainless Tubing!

Here are some of the *reasons why* Carpenter Welded Stainless Tubing is easy to fabricate. And today, easier fabrication means *more output . . . fewer spoiled jobs,* even in the hands of semi-skilled workers.

1 *Uniform tube walls* permit the use of lighter gauges, without sacrificing strength. *Lighter gauges* mean easier and faster bending, cutting, expanding, welding, etc.

2 Carpenter Welded Stainless Tubing is naturally *easy to form* because it is made from *ductile* cold-rolled strip, inspected both sides.

3 As only a *minimum of machining* is needed, this tubing helps to reduce tool troubles. Less machining equals time saved and metal conserved.

4 Tube shapes are *natural design units.* Finished parts or connections can often be made by merely swaging, tapering, flanging or expanding.

5 The *uniform structure* of this tubing eliminates production "bugs" before they start. Even the V-shaped weld is chemically and mechanically analogous to the parent metal.

IF YOU WANT STRENGTH . . . Carpenter Welded Stainless Tubing can provide it! This tubing often supports loads once carried by solid bars. It can withstand pressures once handled by heavier-walled tubing. For instance, the test piece shown here (from a regular production run) was "bent double" along the weld—and refused to break.

If you are doing engineering or research work, or if you want help in fabricating Welded Stainless Tubing, ask for Carpenter's QUICK FACTS bulletins. They can help you get the most from every length of this tubing . . . and a note on your company letterhead will start them on the way to your desk.

THE CARPENTER STEEL COMPANY

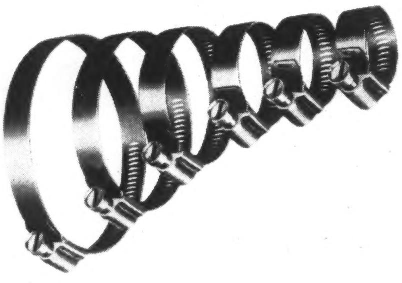
Welded Alloy Tube Division, Kenilworth, N. J.

Carpenter
WELDED
STAINLESS TUBING

sure and severity of service. The wire braid restrains the natural tendency to stretch under pressure and increases strength without affecting flexibility. Armor further increases strength and protects hose against abrasion. The hose is usually furnished complete with either of two types of fittings attached—the "solder-on" for compressed air and cold liquids, and "heat-proof" or brazed couplings, where heat encountered is sufficient to melt solder. Another hose—a seamless steel hose—manufactured by the company, is a strong, vibration-absorbing hose that withstands high temperatures and is widely used as a flexible exhaust connection between engine and silencer on leading stationary, automotive and marine diesel engines.

Self-Locking Hose Clamp

RECENTLY introduced by The Aircraft Standard Parts Co., 1711 Nineteenth avenue, Rockford, Ill., a line of "Aero-Seal" hose clamps is now available in fourteen sizes from ¾-inch to 4 inches inside hose diameter. A number of improved and interesting features have been incorporated in the design, which meets Army Air Force Specification No. 25529. The clamp consists of a 9/16-inch tempered steel band punched with holes corresponding to the teeth of a wormwheel. These holes mesh with a worm screw in the housing welded to the fixed end of the band. The head on the worm screw is fitted with a safety cup which prevents slipping and puncturing of hose. Rapid action is obtained by a ten-pitch thread so that full take-up is obtained with only a few turns of the screwdriver. The belt-like tightening action produces a uniform tangential pull which does not distort the pipe and results in leakless clamping. By backing up the screw the free end of the band comes out of the housing, and the clamp may then be sprung open and slipped over the hose in place on the pipe. The hose clamps are self-locking as a result of the worm and worm gear action and will not loosen even under severe vibration as long as the band is under tension. All parts of the hose clamp are heat treated as necessary to provide strength, durability, freedom from distortion, and freedom from wear between the parts.



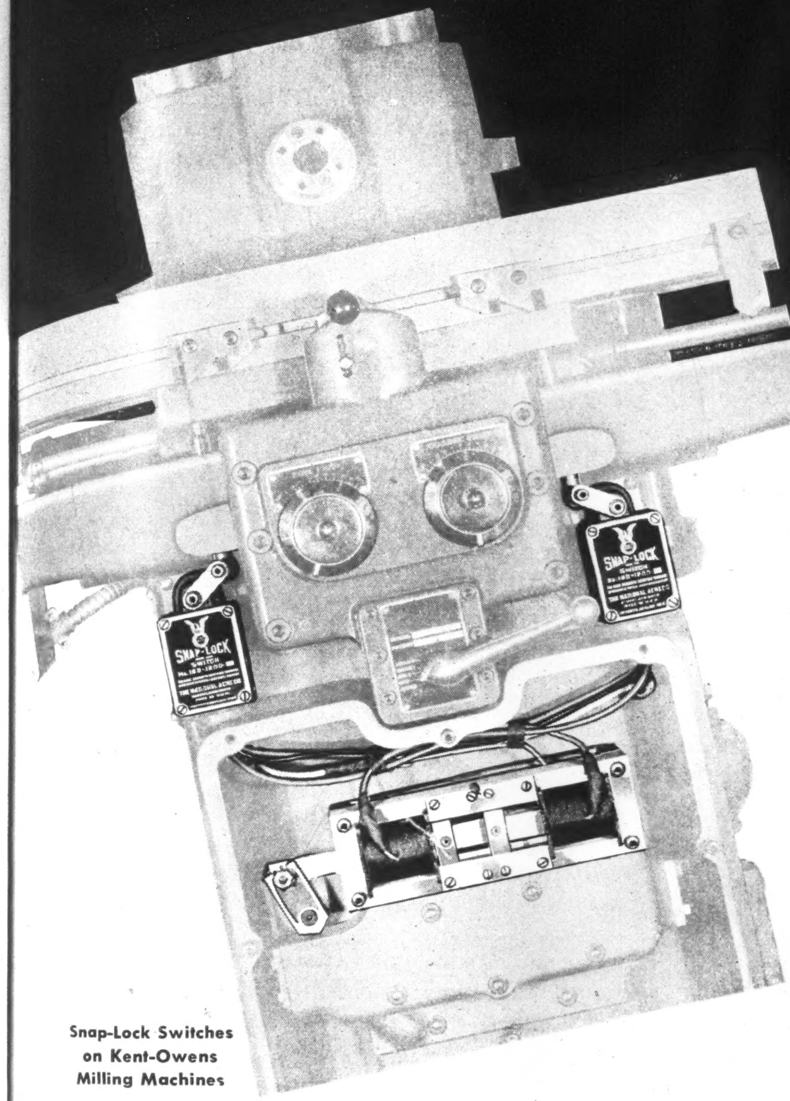
Vibrating Reed Frequency Meter

USED on engine generator sets in laboratories, in telephone, television and radio service, in many types of electronic equipment, on panel and control

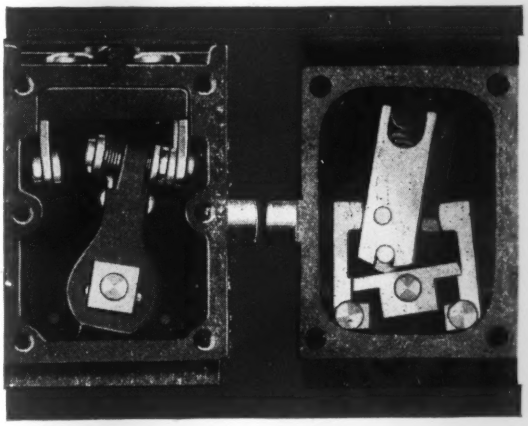
Electric Brains and Hands FOR HEAVY DUTY MACHINES

SNAP-LOCK
TRADE MARK

Built by Machine Tool Builders for Machine Tool Builders



Snap-Lock Switches on Kent-Owens Milling Machines



SIMPLE . . . SAFE . . . SURE . . . LONG-LIVED

Separate enclosures for mechanical and electrical sides, as shown, are an exclusive Snap-Lock safety feature. Single-pole, double-break, double-throw. Unusually strong dielectric case resists oil, dust and moisture. Snap make and break. Positive locking in either position—no half-on or half-off possible. Heavy coin silver self-wiping contacts. Hardened steel, cadmium-coated parts.

Snap-Lock Limit Switches are built to provide a safety factor so great that switch failure has yet to be heard of—even in 7-day, 24-hour production.

First designed and built for Acme-Gridley Automatics, they were proved in our own shop, and made standard equipment on our own product, where we just can't afford to be wrong.

Snap-Locks have been adopted by 80% of the builders of heavy-duty, precision machines, for both built-in and replacement application—and still not a single failure to perform has been reported!

Bulletin EM-42 will show you the wide variety of conditions met by these utterly dependable switches.

ELECTRICAL MANUFACTURING DIVISION

THE NATIONAL ACME CO.

170 EAST 131ST STREET • CLEVELAND, OHIO

ACME-GRIDLEY 4-6 AND 8 SPINDLE BAR AND CHUCKING AUTOMATICS • SINGLE SPINDLE AUTOMATICS • AUTOMATIC THREADING DIES AND TAPS • SCREW MACHINE PRODUCTS • THE CHRONOLOG • LIMIT SWITCHES • POSITIVE CENTRIFUGE • CONTRACT MANUFACTURING

IT'S THE KNOW-HOW, PLUS LATEST EQUIPMENT THAT PUTS SUPERIOR QUALITY INTO

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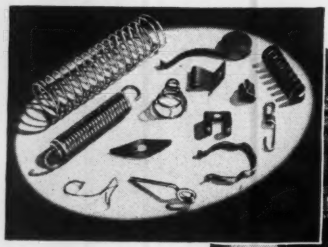
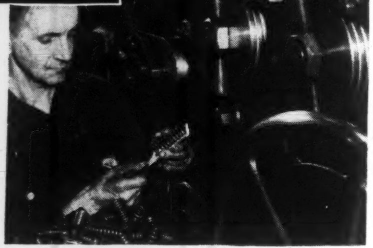
BY
Mid-west





MID-WEST'S plant is fully implemented and manned by engineers, technical staff, operatives and supervision to produce

ANY QUANTITY FOR PROMPT DELIVERY

Midwest PRECISION SPRINGS

COMPRESSION
EXTENSION
TORSION
FLAT SPIRAL
FLAT
SPECIAL TYPES
and
WIRE FORMS

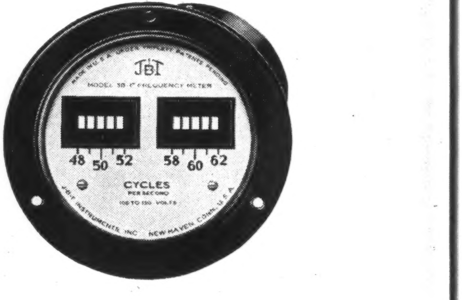
Contract manufacturing, short runs or production orders. Any type and size of industrial or mechanical springs, any metal. *Precision-made* to your B/P., specifications or samples. Also stamping, sheet metal, and small, and light metal Aircraft Assemblies. Let us estimate. You'll be pleased with our figures.

SEND FOR *NEW* QUICK FINDING SPRING GUIDE

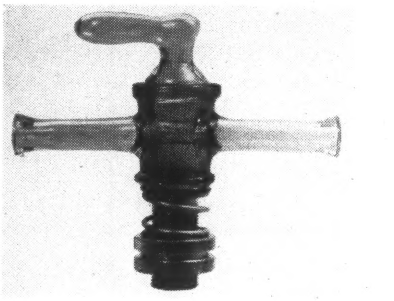
Just off the press. FREE to Executives and Engineers. Complete up-to-the-minute spring engineering data. Have it in file for ready reference. Write

MID-WEST SPRING MFG. CO.
4644 S. WESTERN AVE. *Phone Lafayette 1743* CHICAGO, ILLINOIS

boards, the new Model 30-F vibrating reed frequency meter announced by J-B-T Instruments Inc., New Haven, Conn., is simple in design. It consists of a case, base, dial, central mounting frame, a series of spring steel reeds screw to a fixed reed mounting bar, an individual driving coil surrounding each bank of reeds, a permanent magnet, a series resistor and terminal studs. The alternating current (or interrupted direct current) excites the driving coil. As each reed is adjusted to respond by resonance to but one frequency, the one reed "in tune" with the frequency in the coils will respond by vibrating rapidly because of polarization by the permanent magnet, and induced magnetism from the coil. A series resistor adopts the instrument to specified operating voltage. The frequency of the current can be read opposite that reed on the graduated face of the instrument. Reeds are made from a special alloy steel which has an unusually high fatigue strength for continuous operation, and to prevent failure through oxidation, each reed is coated with a nonvolatile lacquer. An average of less than 2 watts—and as low as ½-watt—at 115 volts, depending on the model, is consumed. The meter is furnished in a wide voltage range—from 8 volts up. Above 500 volts, an external series resistor is used. Normal range is ±20 per cent of specified voltage on frequencies outside the reed range—a 50 to 75 per cent increase is permissible.


JBT
MODEL 30-F FREQUENCY METER
48 50 52
58 60 62
CYCLES
PER SECOND
J-B-T INSTRUMENTS INC NEW HAVEN CONN. U.S.A.

Flanged Glass Pipe and Fittings



FLANGED piping of heavy-walled Pyrex tubing, made by Fischer & Porter Co., Hatboro, Pa., is filling a need in the process industries occasioned by the war. It is made in four sizes — ¼, ⅜, ½ and ¾-inch—of heavy gage Pyrex. Standard Corning-type flanges of cast iron are used to put the piping together. It is available in straight lengths, tees, elbows, crosses, U-bends, short nipples, reducers and a variety of other standard fittings, while special designs are made to order. The tubing will stand 400 pounds per square inch working pressure in lengths up to 1 foot, and in 6-foot lengths will take 140 pounds per square inch. When put to-

MAGNESIUM
FOR
WARPLANES
AND FOR YOUR
POSTWAR PLANNING

This Mazlo Magnesium permanent-mold casting is an airplane starter-motor housing, one of many thousands made by American Magnesium Corporation. Magnesium contributes the lightness and high strength so necessary in aircraft; "Know-how" contributes the soundness and accuracy of detail that simplify and speed manufacturing.

Where parts are required in sufficient quantities, permanent-mold castings offer these advantages over sand castings: Surfaces are smoother and grain structures finer. Dimensional tolerances are closer, so castings can be lighter and need less machining. Costs of finished parts are usually less.

After the war, there will be a wealth of capacity to take care of your permanent-mold casting requirements—many times that of prewar industry.

Magnesium alloys have casting characteristics peculiar to themselves, in addition to low specific gravity. This means that the methods of gating, chilling and coring, and how the metal is handled, all affect the quality of castings. That's where our experience can serve you best.

Twenty years of working with magnesium alloys have taught us *how.* American Magnesium engineers and plant men offer you that guidance. Sales Agent for Mazlo Magnesium Products: Aluminum Company of America, 1703 Gulf Building, Pittsburgh, Pa.

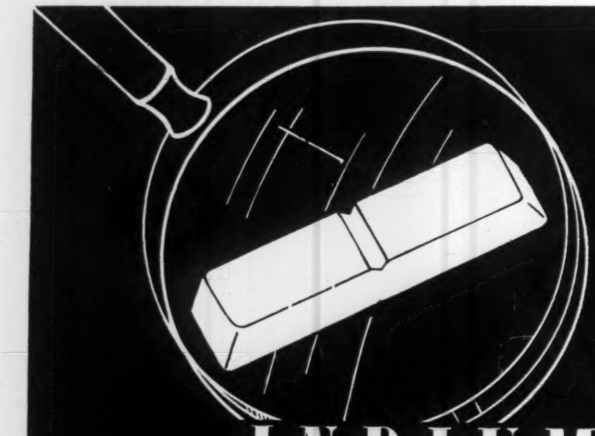
MAGNESIUM **MAZLO** PRODUCTS

REG. U.S. PAT. OFF.

AMERICAN MAGNESIUM

CORPORATION

SUBSIDIARY OF ALUMINUM COMPANY OF AMERICA



INDIUM

Investigate Its Merits!

for...

1 . . . improving the tensile strength and fatigue resistance of non-ferrous metals you are using; or

2 . . . improving the wear-resistance and corrosion-resistance of bearing metals; or

3 . . . improving the decorative or industrial finishes of polished articles; or

4 . . . improving contact points for electrical equipment; or

5 . . . improving the usefulness of silver, a metal that has many potential industrial applications.

We say "Investigate the Merits of INDIUM" because we have seen its adoption in many plants bring about great improvements in products or satisfactory alternates for certain strategic but scarce materials formerly used. As the authority on and principal suppliers of this relatively new metal in the industrial world, we shall be glad to help study its possibilities for your products.

ARMY E NAVY

THE INDIUM CORPORATION OF AMERICA · Pioneers · In 49 element

THE INDIUM CORPORATION OF AMERICA

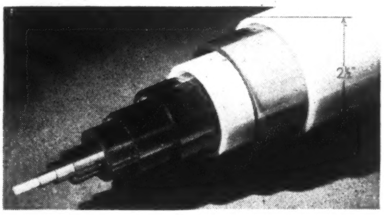
UTICA, N. Y.

New York Office: 60 East 42nd Street

gether, it will firmly support itself and resist shock or heavy external blows, and will handle all corrosive fluids with the exception of hydrofluoric acid and strong, hot caustic soda solutions. The company also offers a Pyrex stopcock (illustrated), for these lines with a special metal spring-loading device that enables the stopcock to take pressures equal to those given above for the piping without blowing out the plug or harming the valve body. The tubing is carried in stock, enabling fast deliveries of standard sizes with a low priority; even special sizes can be fabricated within two to three weeks.

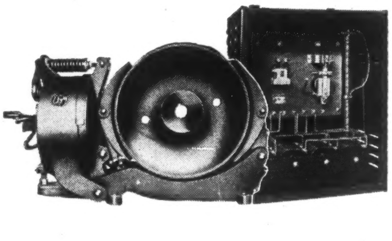
Seamless Plastic Tubing

TO MEET the demands of the war industry, Extruded Plastics Inc., Norwalk, Conn., has made available its Tulox TT seamless plastic tubing in all sizes up to 2 inches outside diameter. This range will be increased shortly to 2½ inches outside diameter to meet requirements of war production. The tubing, extruded from cellulose acetate butyrate, is available from warehouse stocks throughout the country through Crane Co., Chicago and Julius Blum & Co. Inc., New York city.



High-Speed, Magnetic Brakes

BRAKES for use with alternating-current motors announced by The Electric Controller & Mfg. Co., 2700 East Seventy-ninth street, Cleveland, are of the high-speed type in that they release and are also arranged to set quickly, making possible accurate inching on cranes, hoists, conveyors, rotating machinery, etc. Spring-set and magnetically released, this Type WB brake has no laminated magnets or plungers, no destructive hammer-blow and no alternating-current chatter. It has thick, molded brake blocks, ¼-inch thick on the smallest size brake to ¾-inch on the largest size which permits ⅛ to 7/16-inch wear per shoe before reblocking is necessary. Standard type WB brakes for alternating-current applications include the proper size of brake with Ecamite wheel for



Metal Hose on the War Job—

GRINDER DUST, CARTRIDGE CUPS, LUBRICATING OIL

Extra protection for workers. This section of Steel Interlocked Hose sucks abrasive dust from grinding wheels . . . a "safety" application of American Flexible Metal Hose that affords protection for employees and thereby helps cut absenteeism and lost time.

Constantly soaked in grease. Five lengths of Flexible Interlocked Steel Tubing convey cartridge cups into pans as they are punched out by this blanking machine. Entire operation is bathed in lubricant and grease—but it can't rot or damage this all-metal construction in the least. Can be bent to any position to act as a "chute".

Flexible Oil Feed and Coolant Tubing is a special product of American Metal Hose for machine tool applications. Furnished in any length as required, this flexible metal tubing easily bends to any desired position, and *stays put* when bent.

Using virtually any workable metal, we can furnish flexible hose or tubing for anything from a simple spout to a high pressure hydraulic line (*American Seamless*) that can be flexed millions of times without breaking.

If you need a flexible connector for conveying air, water, oil, steam or fuel—for connecting misaligned or moving parts, or isolating vibration—chances are we have a type of hose or tubing that will do the job better. Complete descriptive literature available on request. 43199

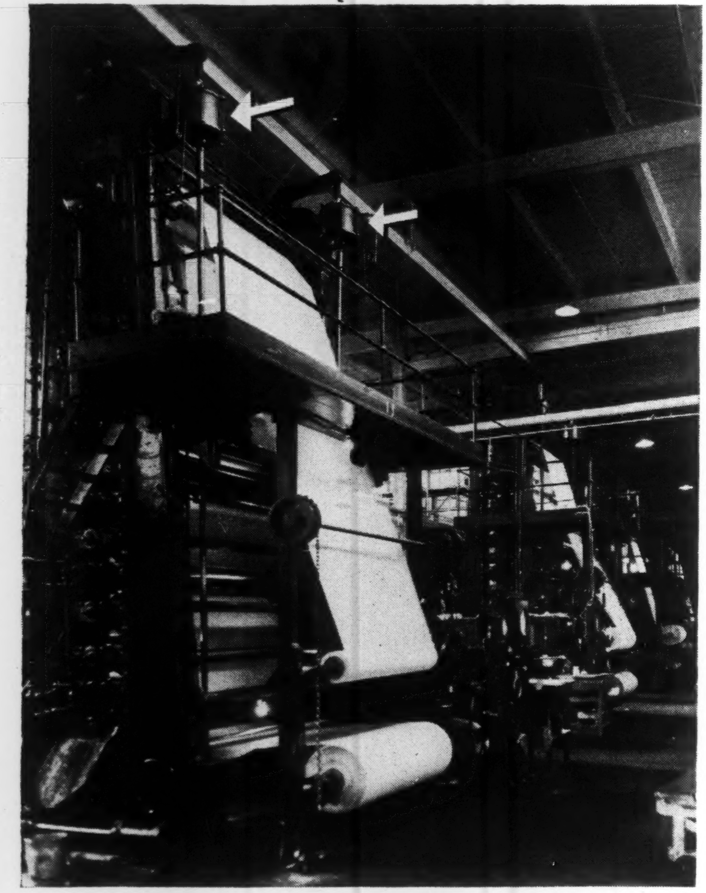
AMERICAN METAL HOSE BRANCH
OF THE AMERICAN BRASS COMPANY
General Offices: Waterbury, Connecticut
Subsidiary of Anaconda Copper Mining Company
In Canada: Anaconda American Brass Ltd., *New Toronto, Ontario*

ANACONDA

American Metal Hose

HANNIFIN CYLINDERS

USED IN CONTROLLED PNEUMATIC LOADING SYSTEM



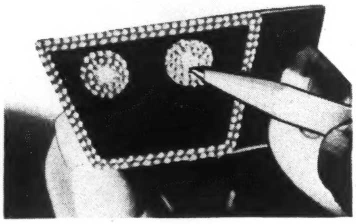
Foxboro controlled pneumatic loading for press rolls and other machinery provides uniform roll pressures, easily and accurately controlled, with many advantages over former weight loading methods. The pneumatic pressure is applied by Hannifin pneumatic cylinders as shown here. This simple application of an air cylinder illustrates the adaptability of Hannifin cylinders and the advantages of pneumatic power. Pressures are precisely and uniformly controlled and easily duplicated for successive runs.

Foxboro selected Hannifin pneumatic cylinders because their precision construction assures minimum friction and high efficiency operation. Investigate the advantages of pneumatic power and Hannifin cylinders. Write for Bulletin 57-MD giving complete specifications.

HANNIFIN MANUFACTURING COMPANY
621-631 South Kolmar Avenue Chicago, Illinois

floor mounting, copper-oxide rectifier, double-break contactor between rectifier and brake, and current-reducing adjustable resistor and relay. If required, the brake can be arranged for vertical or inverted mounting. A single rectifier-unit of suitable capacity for operation of two or more brakes from the single unit may also be obtained. Air-applied or combined air-released and magnetically-released brakes are also furnished by the company.

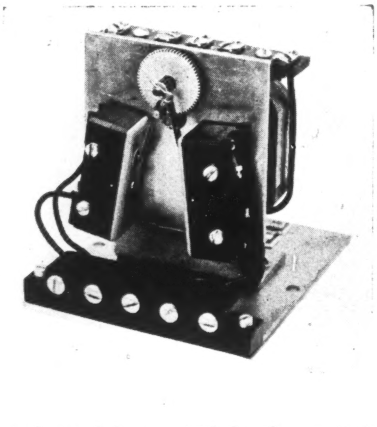
V-Belts Are Wire-Reinforced



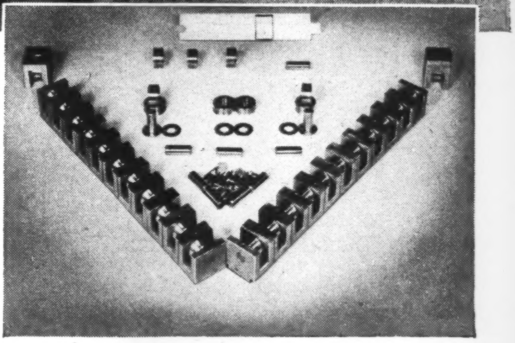
WIRE-REINFORCED V-belts are being built by The B. F. Goodrich Co., Akron, O., in two types—a cable cord construction and grommet construction which incorporates a wire cord placed in the center of a cotton or rayon grommet. Advantages of the wire-reinforced V-belt, designed for the most rigorous service, are: Greater horsepower capacity and increased tensile strength and low stretch. Emphasis has been placed by the company on the fact that only after full engineering details of the equipment on which the belt may be used and operating conditions are studied will it be able to decide whether a wire belt will be practical.

Motor Has Built-in Limit Switches

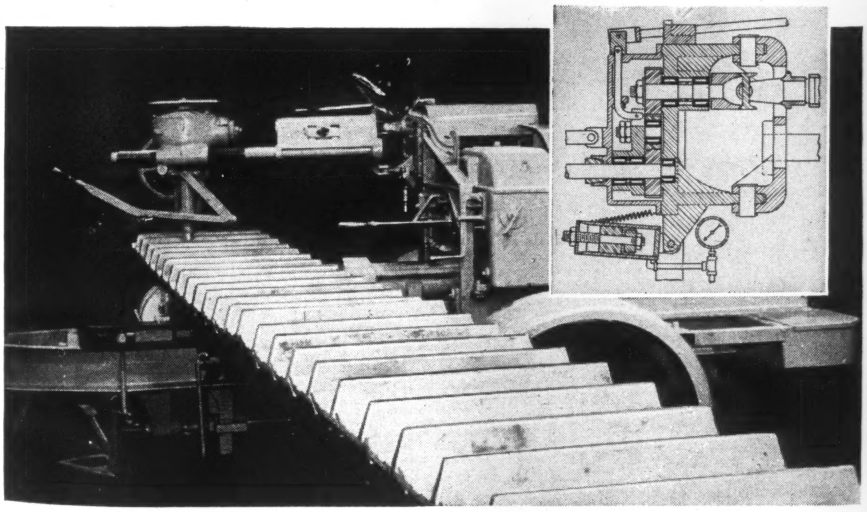
USED with any floating contact device in applications where the control current exceeds the contact rating of the control instrument, the motor relay announced by Barber-Colman Co., Rockford, Ill., consists of a reversible geared head motor, totally enclosed switches, switching mechanism, and terminal, all mounted on a cadmium-plated steel base. While the unit is unenclosed an enclosed type drawn steel cover is available. Switch contacts have a noninductive load capacity of 10 amperes at 110 or 220 volts, or 5 amperes at 230 volts alternating current. Control circuit is .35 amperes at 25



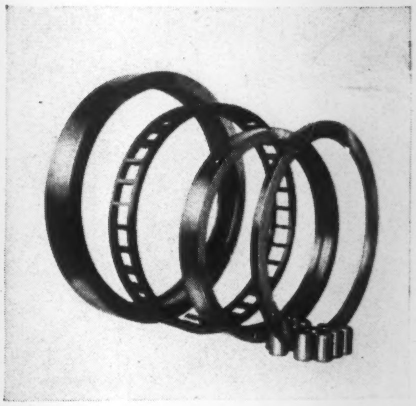
IN THE NEWS
WITH BANTAM BEARINGS



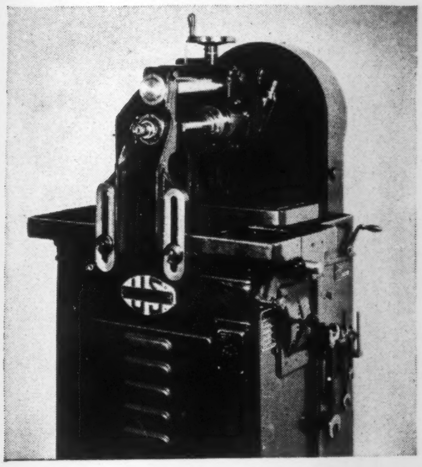
"SEWING" SHEETS OF STEEL together rapidly with dependable welds to speed shipbuilding is the work of The Linde Air Products Company's "Unionmelt" welding machine. Special anti-friction bearings built by Bantam are used on the pressure and straightening rollers which feed the welding rod. These bearings, shown unassembled in the inset above, assure long, trouble-free service and are typical of Bantam's ability to provide bearings for special applications of all types.



UNLOOSENING ROCK-BATTERED BOLTS on the caterpillar tracks of tanks and tractors is the tough maintenance job performed by this track wrench, a product of Rodgers Hydraulic Incorporated. Despite the unusually heavy stresses encountered, dependable power transmission is assured by the high load capacity of eight Bantam Quill Bearings and four Bantam Needle Roller Bearings used in the gear mechanism. In addition, these bearings contribute to compact design because of their small size, as can be seen from the accompanying cross-section drawing, and to low power consumption because of efficient lubrication and low friction coefficient.



SIMPLER, MORE EFFICIENT PRODUCT DESIGN AND ASSEMBLY is often achieved by the use of special types of bearings such as these Bantam Journal Roller Bearings built for use in the crown and traveling blocks manufactured by Emsco Derrick & Equipment Co. Measuring 27½" O.D. they are provided with thrust shoulders built into outer races to eliminate hazardous thrust washers and contribute to compact design. Bantam's engineering and manufacturing facilities are geared for the prompt delivery of such special bearings for essential purposes.



LOW STATIC FRICTION of a Bantam Quill Bearing aids in actuating a safety-stop device on the cam-feed mechanism in this U. S. Tool Company "Multi-Miller," by allowing a normally stationary high-friction bearing on the camshaft and inside the Quill Bearing to turn when pressure on the shaft approaches the overload point.

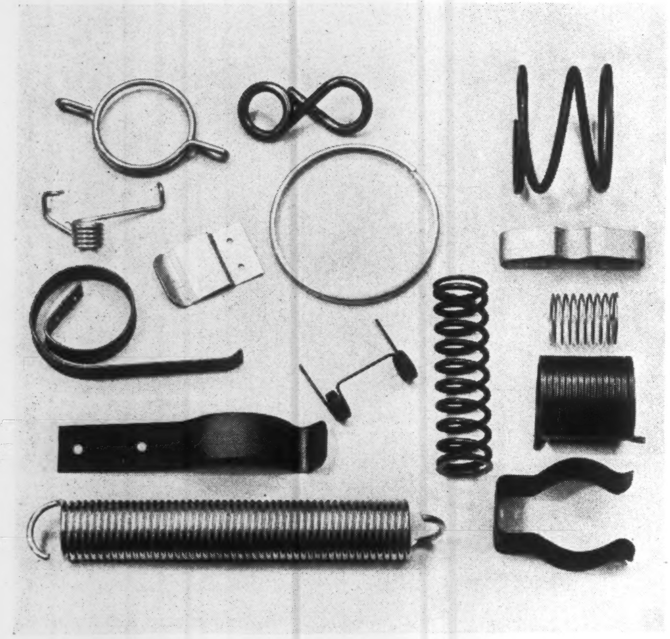
EXPERIENCED SKILL TO SERVE YOU in the unbiased selection of standard bearings or in the design of bearings for unusual applications is offered by Bantam's engineers. Bantam makes every type of anti-friction bearing—straight roller, tapered roller, needle, and ball. No matter how difficult your bearing problem, TURN TO BANTAM.

ARMY E NAVY

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION
SOUTH BEND, INDIANA



SPRINGS *Help Win the War!*

Reliable

In the countless jobs which springs of every type must do in equipment for our fighting forces, Reliable Springs play an important part. Every day many thousands of Reliable Springs are contributing their accuracy of action, their dependability, to the total war effort.

Our expert engineering, tool and die, and testing departments assure competent attention to *your* specific problem. On difficult requirements, where ingenuity and "hair-splitting" care are called for, Reliable is at its best. Our equipment for coiling, shaping, heat-treating, precision grinding and testing, is the finest obtainable. Whether your need is for compression, extension, torsion or flat springs, of any material—Reliable is set to give you the *best* spring for the job.

When American industry returns to the tasks of Peace, Reliable will be ready to help you apply to your product the benefits of those economies and improvements in spring making, which have evolved under war-time conditions.

Send us your specifications and drawings.

THE RELIABLE SPRING & WIRE FORMS CO.
3167 Fulton Road **Cleveland, Ohio**

Representatives in Principal Cities

YOU CAN RELY ON
Reliable Springs
ROUND AND FLAT WIRE SPRINGS
CLIPS HOOKS BENDS LIGHT STAMPINGS

volts. When one pair of shading coils is energized from the control circuit, the motor runs to a mechanically stalled position, closing the corresponding switch. When shading coil circuit is opened, motor returns to mid-position and opens the switch. Chattering is eliminated because a momentary contact at the controlling instrument will not cause the motor relay to run long enough to close a switch circuit. Dimensions of the motor relay are 4⅛ inches high, 4¼ inches long, 3¾ inches wide.

Photoelectric Controls Announced

AN OUTSTANDING feature of the new Series 70 photoelectric controls announced by United Cinephone Corp., Torrington, Conn., is the flexibility with which they may be adapted to a wide variety of applications. Life expectancies of the average control range as follows: Light source bulbs to 2000 hours, amplifier tubes (6J5) to 3500 hours, photocell tubes to 10,000 hours, and practically indefinite life for other components. Contact capacity for Model 70 is 3 amperes; current capacity 110 volts, 60 cycles, alternating current. Where applications require heavier duty contacts, a noninductive microswitch may be added, mounted on sensitive relay, which will increase contact capacity to 10 amperes. If it is not possible to utilize the light source current supply provided by the photo-control, Model 18A-1 light source can be operated directly from any alternating-current outlet. A further advantage obtained from this unit is the choice of high or low intensity of light. The Series 18 light sources are supplied in two types: Without transformer, operating current supplied by control; or with transformer, direct from 110 volts alternating current.

UNITED CINEPHONE CORP.
TORRINGTON CONN.
U.S.A.
UNITED CINEPHONE CORP.
TORRINGTON CONN.
U.S.A.

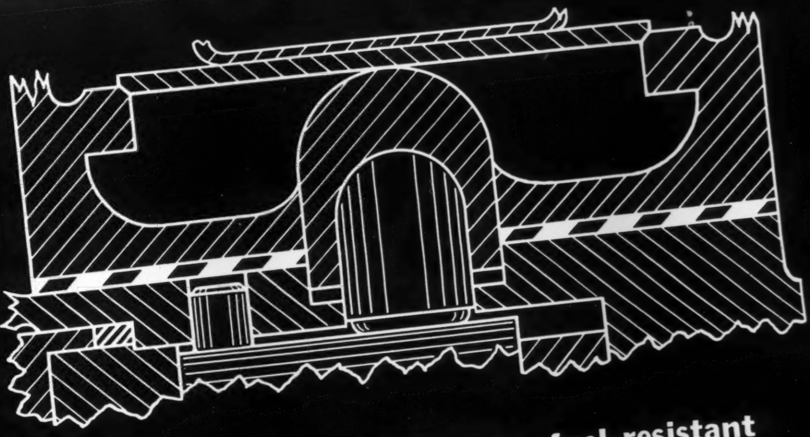
Cellulose Acetate Plastic

DEVELOPED by Plastic Fabricators Inc., 440 Sansome street, San Francisco, a cellulose acetate plastic, Durashield, can be fabricated to almost any size, shape, thickness or color scheme. It can be die cut readily and will permit punching of holes of any size in accord-

CASE HISTORY
No. 202

GASKETS

PROBLEM: To find a fuel pump gasket—resistant
- **to aromatic blend gasoline—which would compress without side flow**



▨ **Compressible, fuel-resistant gasket of one of Armstrong's Cork-and-Synthetic-Rubber Compositions**

A MANUFACTURER of aircraft equipment was faced with a serious bottleneck in the assembly of fuel pumps. The root of the trouble was the thin flange gasket, which had been selected because it was impervious to aromatic fuel. This gasket was noncompressible. Thus it would side flow unevenly under pressure unless the tension was exactly adjusted on each bolt. Time-consuming care was required to prevent leakage.

Solution

The problem of supplying a gasket that would break this bottleneck was given to Armstrong's sealing specialists. They recommended one of Armstrong's Cork-and-Synthetic-Rubber Compositions. The cork in this composition assures true compressibility, without side flow. The synthetic rubber makes it immune to deterioration by aromatic blend fuel. The Armstrong Composition worked out so successfully that, today, the same company is using it in many other sealing applications.

Rolls, Gaskets, Special Shapes

The solution to *your* sealing problem may likewise be found among the more than fifty Armstrong Sealing Materials. See the list of general types below. Compositions having practically any desired physical properties are available in rolls, sheets, die-cut parts, and molded or extruded shapes. Write for your free copy of the catalog describing these materials. Address Armstrong Cork Company, Industrial Division, 5105 Arch Street, Lancaster, Pennsylvania.

ARMSTRONG'S
GASKETS · SEALS · PACKINGS

Synthetic Rubbers • Cork-and-Synthetic-Rubber Compositions*
Cork Compositions • Cork-and-Rubber Compositions
Fiber Sheet Packings • Rag Felt Papers • Natural Cork

*FORMERLY "CORPRENE"

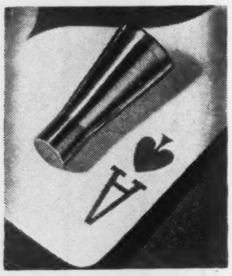
Advertisement

PRECISION PARTS

The Punch Behind

THE BULLET'S PUNCH

Untold millions of rounds of ammunition are going to dozens of fighting fronts. Lives, skirmishes, battles, victory itself depend on the uniform accuracy of every shell, on its ability to slip smoothly into the breech, to fire accurately, and to eject itself instantly. The incredible accuracy that keeps guns from jamming is a job for Ace.

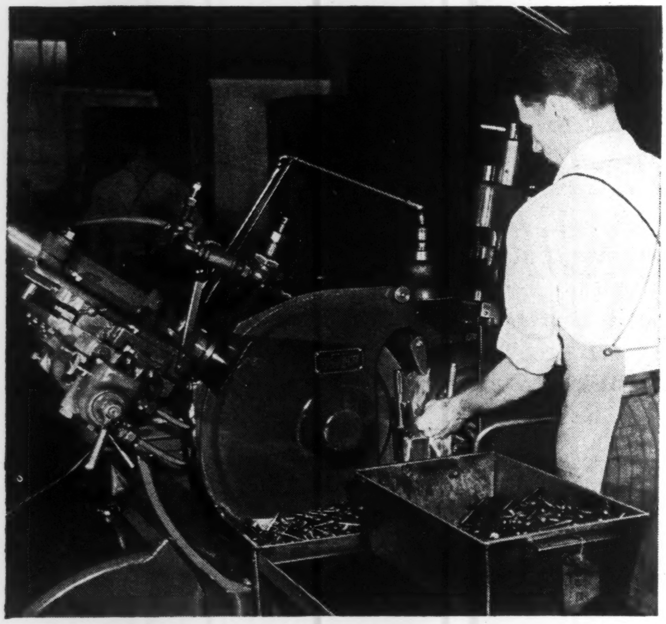


Centerless Ground on 2 diameters and a taper.

This hardened steel cartridge-forming punch is ground out by the thousands in the Ace Centerless Grinding Department. Few people realize that this kind of tapered-and-straight cylindrical contour can be produced without centers, and few plants can do it. Yet Ace men and women, Ace precision machines, finish them in a single operation—with a roundness of the small and large diameters and an accuracy-of-taper that never vary by more than three ten-thousandths of an inch.

Successful post-war products will make use of war-taught accuracy, war-winning tricks of internal, external and Surface Grinding of steel, non-ferrous metals, glass and plastics. Ace can help you produce (or prepare to produce) small precision parts in volume. Send samples or sketches and have an Ace up your sleeve.

Close tolerance on a volume basis.



ACE

TRADE MARK

ACE MANUFACTURING CORPORATION

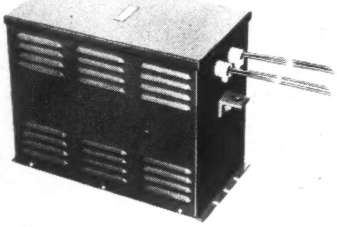
for Precision Parts

1201 E. ERIE AVENUE, PHILADELPHIA

ance with specifications. Cellulose acetate laminated signs of the type and character of this material have been approved by the United States Navy and Maritime Commission and certain units of the United States Army and Marine Corps. It is also being used for name and instruction plates on ships, machinery and equipment. Tests indicate that it can withstand water, salt solutions, oil, gasoline, paint and impact. The material also meets the Navy specifications for being fire retardent. Made to withstand temperatures from 140 to 200 degrees Fahr., the material can be used where brass, bronze or copper nameplates have been used, all the way from nameplates to dial faces.

Stabilizer for Voltages

FOR application wherever close voltage regulation is required, General Electric Co., Schenectady, N. Y., has introduced its new voltage stabilizer which provides a constant output of 115 volts from circuits varying between 95 and 130 volts. It is not affected by variations in load from no load to full load, or by changes in power factor from unity to .8 lagging. Completely self-protecting, it will operate continuously throughout the range from open circuit to short circuit without damage. The stabilizer is used in radio transmitters, electronic-tube apparatus, motion-picture sound equipment and projectors, telephone apparatus, X-ray machines, and in calibration of meters, instruments and relays. It is rated from 50 va to 5000 va.



Engineering Dept. Equipment

Drafting Room Lighting

FEATURES of the Admiral lighting unit for drafting rooms, announced by The F. W. Wakefield Brass Co., Vermillion, O., include direct distribution of light—approximately 90 per cent downward—adequate louvers to prevent direct view of the lamps, and an even brightness over bottom of unit to provide "skylight" effect. The unit is pleasing in appearance, having a walnut finished birch frame with wood louvers finished with infrared baked white synthetic enamel. Hangers are of steel, finished to match in baked enamel as selected. The fluorescent lamps may easily be replaced by lowering hinged louvers. A narrow 3-inch reflector section eliminates bulky appearance. Immediately above each lamp a narrow section is open to allow some illumination of the ceiling area and

ALL SET FOR
THE BIG LUG

PHOTO BY U. S. ARMY SIGNAL CORPS

OSTUCO *"rides the dusty trails" with our mechanized Army*

OUR all out Army is heading Hitler-wards on wheels because this war won't wait for movements afoot. Thousands of rugged American trucks transport men and materials over roads that are more often byways than highways.

In many of these military trucks, weight support and resistance to gruelling jolts and jars are supplied by parts made from OSTUCO seamless steel tubing. Among those parts are axles, propeller shafts and bearings, piston pins, washers and sleeves. For each application OSTUCO provides seamless steel tubing that meets strict military specifications—tubing that's straight, sound, clean, and free from pits, scores, and other surface imperfections.

Thus OSTUCO now draws on its years of experience to provide seamless tubing that fills the need for strength, hardness, accuracy as to size and gauge, and machinability to help solve vital wartime manufacturing problems. At the same time it is gaining a wealth of new experience to help you meet the new and equally strict demands of competitive, peacetime mass production.

BUY MORE U. S. WAR BONDS • PUT ALL YOUR SCRAP INTO THE FIGHT

THE OHIO SEAMLESS TUBE COMPANY

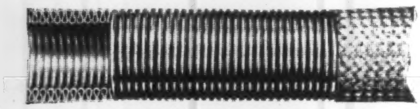
SHELBY
OSTUCO
OHIO

FLEXPEDITE

Your Conversion—Assembly—Production
with

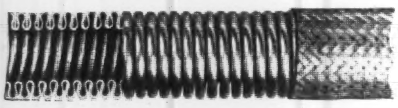
REX-WELD
Flexible Metal Hose

Rex-Weld Hose—Annular Corrugations



RW-80 Unbraided—RW-81 Braided

Rex-Weld Hose—Helical Corrugations



RW-90 Unbraided—RW-91 Braided

—General Data—

	STEEL	BRONZE
Sizes	To 4" I.D.	To 4" I.D.
Pressures	To 14,500 p.s.i.	To 14,500 p.s.i.
Temperatures	To 1000° F.	To 450° F.
Lengths	To 50′	To 50′

—Use Chart—

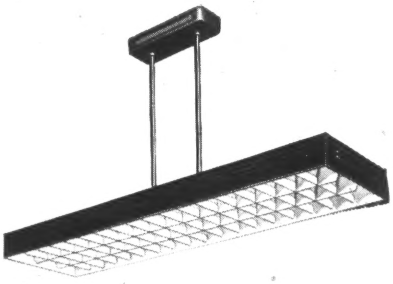
	*STEEL	BRONZE
Saturated Steam		✓
Superheated Steam	✓	
Sulphur Bearing Oil	✓	
Oxygen		✓
Ammonia	✓	
Carbon Dioxide	✓	
Sulphur Bearing Grease	✓	
Critical Vibration		✓
Non-Sparking		✓

*Protective Coatings Can Be Applied for Corrosion Protection (To Conserve Critical Copper Bearing Alloys).

Couplings: REX-TITE Mechanical (Re-attachable) Couplings; Solder Couplings; Brazed and Welded Couplings and Flange Assemblies for Rex-Weld Flexible Metal Hose.
Ask for Engineering Recommendations

CHICAGO METAL HOSE CORPORATION
General Offices: MAYWOOD, ILLINOIS
Factories: Maywood and Elgin, Ill.

to utilize the light which would have been directed back into the lamps themselves. Because of the opacity of the phosphors within the lamps, this is an important feature. The unit is furnished in 4, 8 and 12-foot lengths or for continuous mounting, and is approved by the Underwriter's Laboratory and the Electrical Testing Laboratories.

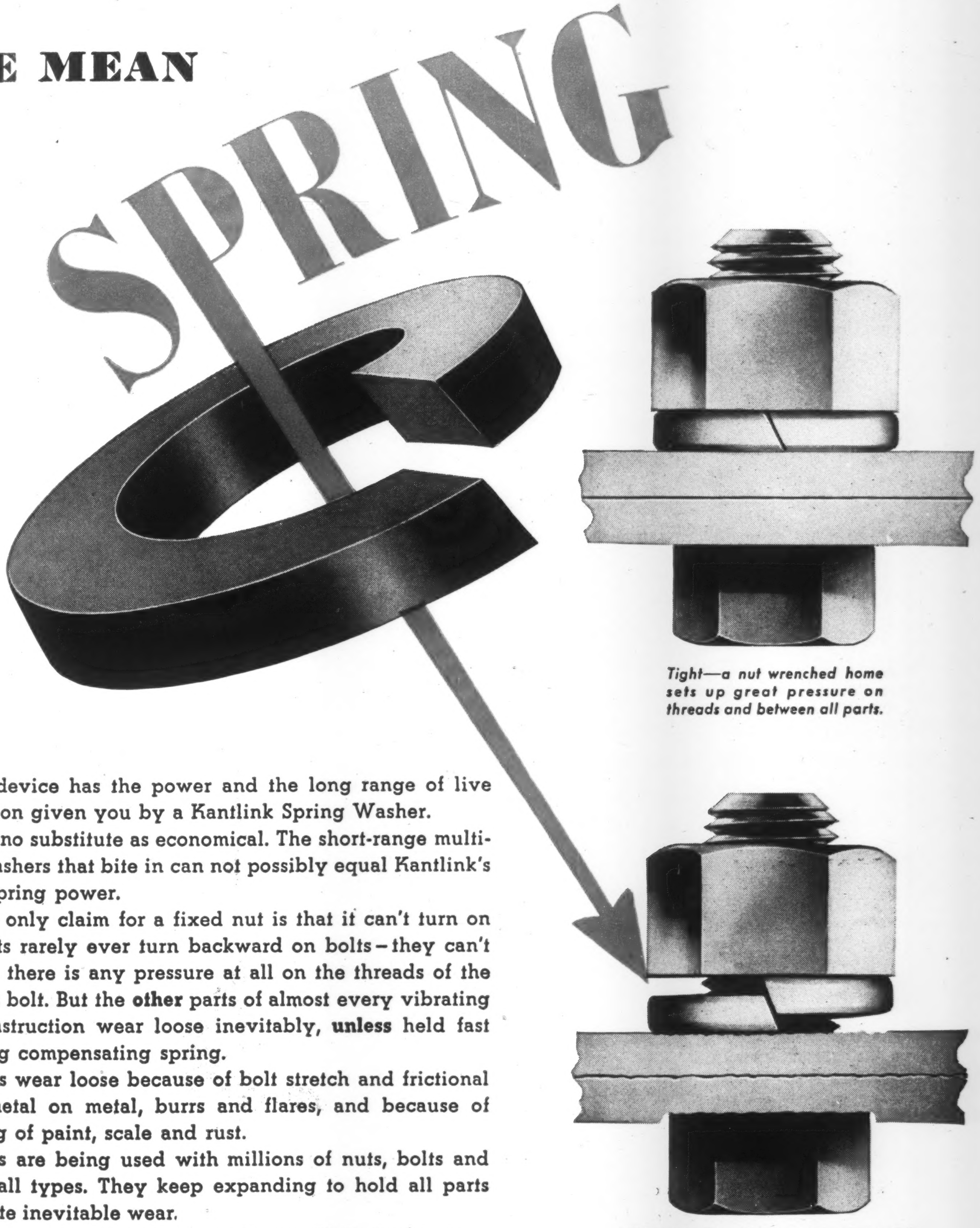


Sound Frequency Analyzer

SIMPLE in operation, the new RA-281 recording sound frequency analyzer of Western Electric Co., 195 Broadway, New York, picks up, analyzes and records a pattern of sound levels extending over a band from 10 to 10,000 cycles in a period of two minutes. Consisting of three units, a special filter, a graphic level recorder and either a moving coil microphone or moving coil vibration pick-up, the standard analyzer covers the frequency range from 10 to 95,000 cycles per second and can examine this entire range on consecutive bands as narrow as five cycles. Analysis is usually by the sweep method, using a hetrodyne analyzer and a synchronous driving motor coupled to the dial. A special quartz crystal filter allows frequencies within the selected band to pass, rejecting energy of other frequencies. Four different band widths are available and any three can be built into the instrument. Output of the analyzer is connected to the graphic recorder which automatically traces on a chart the level of the particular frequency through which the analyzer dial is passing. The unit is compact and light in weight.

When we say "spring"...

WE MEAN



Tight—a nut wrenched home sets up great pressure on threads and between all parts.

Still tight. Though the nut never turned, the other parts wore and stretched. The assembly would have loosened except for the wide range of spring power of a—

No other device has the power and the long range of live spring action given you by a Kantlink Spring Washer.

There is no substitute as economical. The short-range multi-toothed washers that bite in can not possibly equal Kantlink's range of spring power.

And the only claim for a fixed nut is that it can't turn on a bolt. Nuts rarely ever turn backward on bolts—they can't turn while there is any pressure at all on the threads of the nut and its bolt. But the **other** parts of almost every vibrating bolted construction wear loose inevitably, **unless** held fast by a strong compensating spring.

The parts wear loose because of bolt stretch and frictional wear of metal on metal, burrs and flares, and because of pulverizing of paint, scale and rust.

Kantlinks are being used with millions of nuts, bolts and screws of all types. They keep expanding to hold all parts **tight** despite inevitable wear.

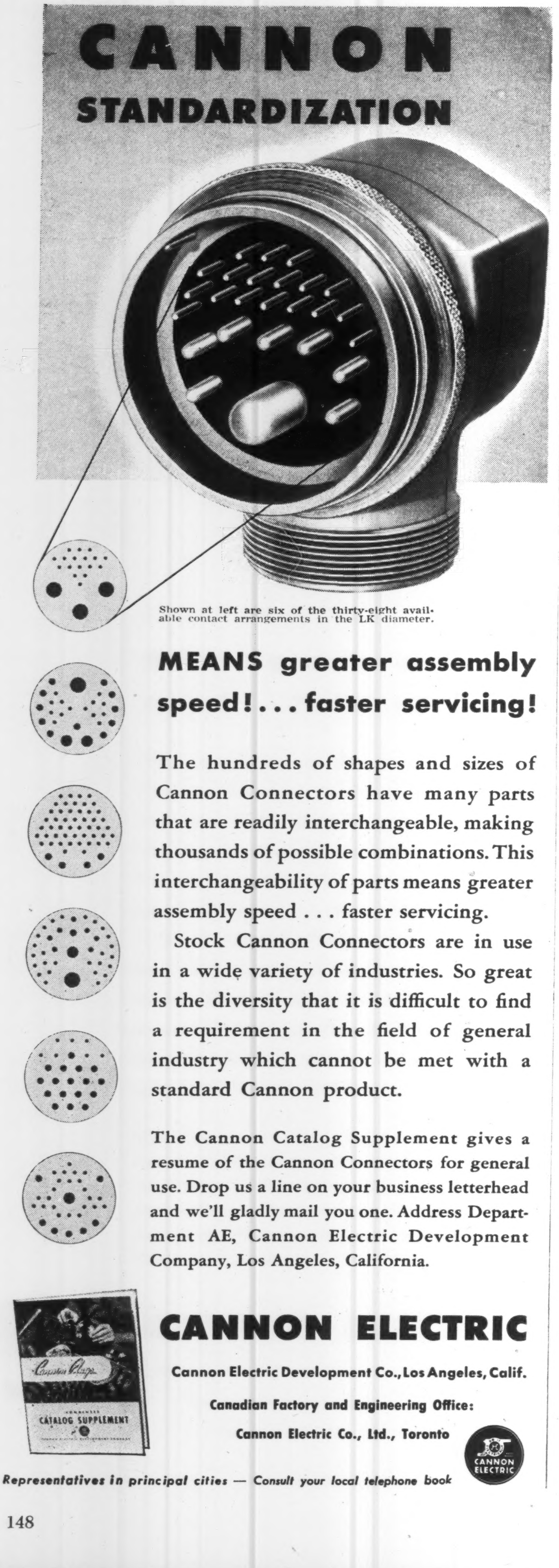
In ordering spring washers—specify **Kantlink,** the big long range live spring washer.

Let us send you samples,—send details of your application. Test and compare them on the same job with **any** type of nut, or with any other type of washer. Kantlinks can't lose a real test. Try them for efficiency, economy and real safety. Write today for descriptive folder.

THE NATIONAL LOCK WASHER COMPANY
NEWARK, N. J., U. S. A.

KANTLINK
TRADE MARK

the long-range Spring Washer



CANNON STANDARDIZATION

Shown at left are six of the thirty-eight available contact arrangements in the LK diameter.

MEANS greater assembly speed! . . . faster servicing!

The hundreds of shapes and sizes of Cannon Connectors have many parts that are readily interchangeable, making thousands of possible combinations. This interchangeability of parts means greater assembly speed . . . faster servicing.

Stock Cannon Connectors are in use in a wide variety of industries. So great is the diversity that it is difficult to find a requirement in the field of general industry which cannot be met with a standard Cannon product.

The Cannon Catalog Supplement gives a resume of the Cannon Connectors for general use. Drop us a line on your business letterhead and we'll gladly mail you one. Address Department AE, Cannon Electric Development Company, Los Angeles, California.

CANNON ELECTRIC

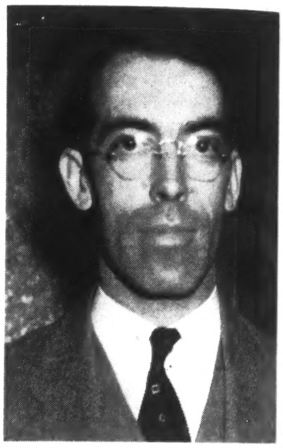
Cannon Electric Development Co., Los Angeles, Calif.

Canadian Factory and Engineering Office:

Cannon Electric Co., Ltd., Toronto

Representatives in principal cities — Consult your local telephone book

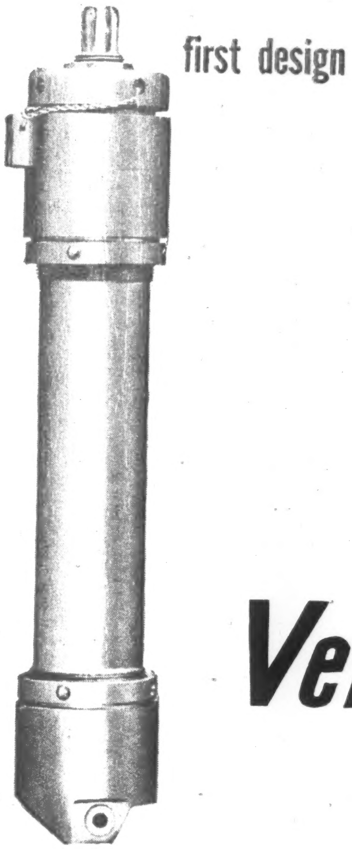
MEN OF MACHINES

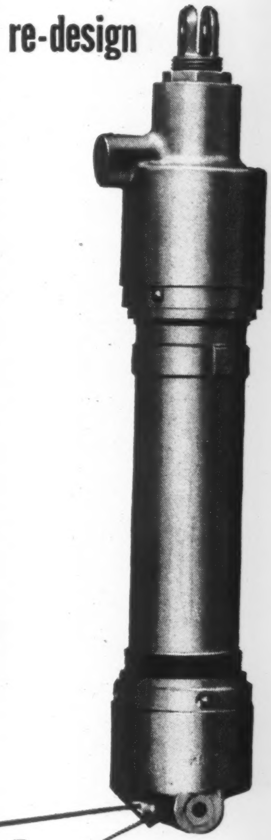


AFTER serving in various engineering capacities since 1931 Fred Pillsbury has been made executive engineer, in general supervision of all engineering work, of the Century Electric Co., St. Louis. Although his record shows only thirteen years of continuous service, he has been connected with the company most of his life. Upon graduating from Clayton High School and Washington university in electrical engineering in 1930 he joined General Electric Co. where he secured his postgraduate training in engineering. Mr. Pillsbury, who is the son of E. S. Pillsbury, president of the company, returned to the Century Electric Co. in 1931.

Another appointment is that of Sam Wolff as chief electrical engineer in charge of design engineering. Mr. Wolff received his education at the R. T. Crane Technical High School in Chicago and at the University of Illinois, from which he was graduated in electrical engineering in 1922. As designing electrical engineer he joined Roth Bros. and continued with this company until 1927 as assistant to its chief engineer. From 1927 to 1934 he was chief engineer of the American Motor division of Thomas A. Edison, Milwaukee, and for two years later was chief engineer of Burke Electric Co. For the following four years he was connected with the Diehl Division of Singer Mfg. Co. as executive engineer. In 1940 he became associated with Century Electric Co. as assistant to the chief engineer.

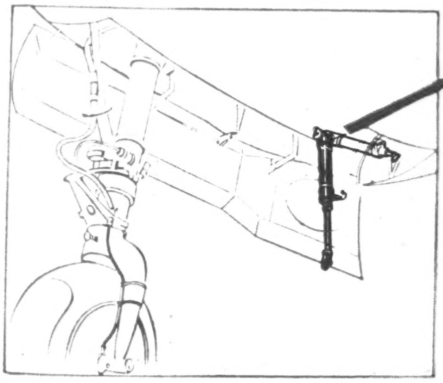
F. RICHARDZ will succeed S. L. CRAWSHAW as manager of gearing engineering department of Westinghouse Electric & Mfg. Co., Nuttall Works. Mr. Richardz has been a member of this department since 1931. Mr. Crawshaw will take up duties as a special assistant to THOMAS J. BAN-





Versatility

. . . . Helped Win Our **E**



VARD is primarily a manufacturer of high precision gages, tools and instruments. Our plant was asked by the Aircraft Industry to produce hydraulic units, and we were awarded a contract to produce cylinders to open and close the landing gear door on American fighting planes.

Our engineers and production men studied the original unit and by careful redesign cut a full 20% off the weight and improved the performance of the unit too.

We are equipped to manufacture the most accurate of turned, threaded, or geared units — and at the same time offer the experience and skill which may improve design, increase strength or save weight.

ARMY E NAVY

VARD INC.

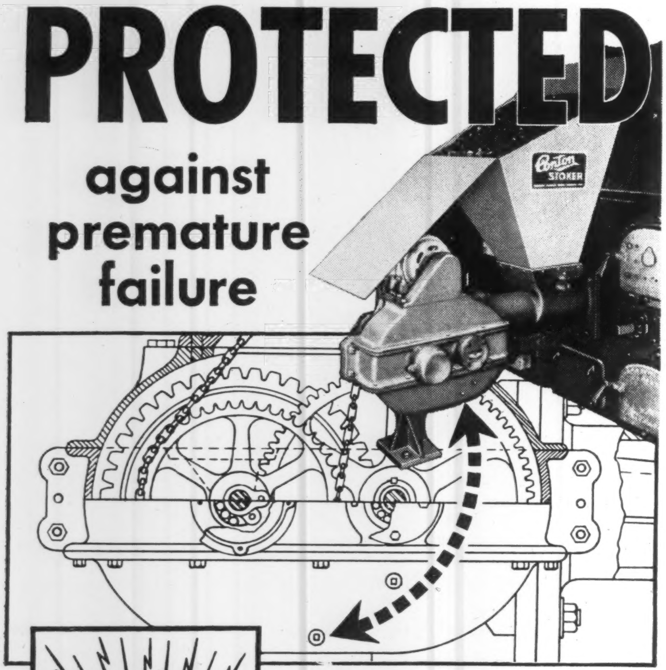
Thread & Plug Gages • Snap Gages • Plain Tapered Ring Gages • Bench Model External Comparators • Dividing Machines • Precision Ground Optical Lenses & Filters • High Fidelity Mirrors

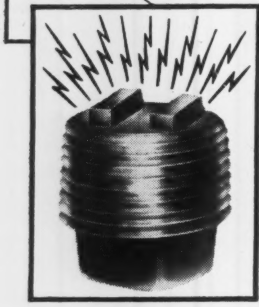
PASADENA, CALIFORNIA

Canton STOKER

BEARINGS PROTECTED

against premature failure



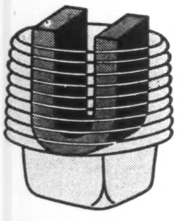


with Lisle Magnetic PLUGS

● A powerful magnet in Lisle Plugs attracts and holds iron and steel particles that form in the lubricant of any gear or bearing housing. Removal of this abrasive metal eliminates one of the most common causes of excessive wear and premature bearing failure. That is why Canton engineers specify Lisle Magnetic Drain Plugs as standard equipment in their stokers.

Lisle Magnetic Plugs offer practical, low cost protection for scores of different applications. **WRITE** for prices and details on free offer of samples to try in your products.

LISLE CORPORATION
Box 1003, Clarinda, Iowa



Phantom drawing shows how a powerful magnet is inserted in each Lisle Plug.

Lisle Magnetic DRAIN PLUGS

NAN, executive vice president of Western Gear Works. He will be located in Los Angeles and will assist Mr. Bannan in engineering and technical matters.

○

DR. ALBERT W. HULL was recently elected president of the American Physical Society. He is assistant director of the General Electric Research Laboratory, and has received honors for his work on X-ray crystal analysis and on vacuum tubes. Many types of electronic tubes, some of which have important war uses, are credited to Dr. Hull.

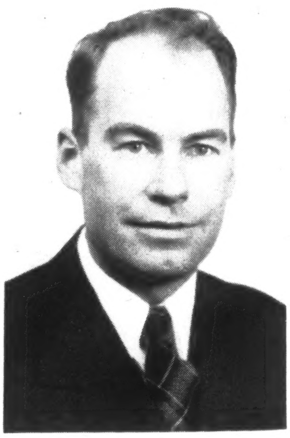
○

CHARLES P. NELSON has recently been promoted to chief automotive adviser and transferred to the Ordnance Service Command Shops, Vancouver Barracks, Wash. Formerly he had been automotive instructor, Ordnance Automotive School.

○

NORMAN W. VAN HUSEN SR. is now president of N. W. Van Husen Engineering Inc., Detroit. He previously was president of Machinery Design Inc., Detroit.

○



ACCORDING to a recent announcement, L. L. Aspelin has been appointed director of engineering of Romec Pump Co., Elyria, O. He formerly was chief of the Fuel Systems Unit, Power Plant Laboratory, with the Army Air Forces in Dayton. Born in 1907, Mr. Aspelin was graduated in 1931 from the mechanical engineering school of Kansas State college with a bachelor of science degree in mechanical engineering. He then obtained a research assistantship at the graduate school, and finished with a master of science degree in 1932. A year later he joined the Kansas State Highway commission and in 1934 the S. A. Long Co., Wichita, Kans., where he devoted his time to air conditioning. Leaving this position he became connected with the Materiel Center, Army Air Forces, Dayton, in 1936—where he remained, as mentioned, until his appointment as director of engineering of Romec Pump Co.

○

FRANCIS J. LINSENMEYER has joined the National Stamping Co. as chief engineer. He resigned as director of mechanical engineering, University of Detroit.

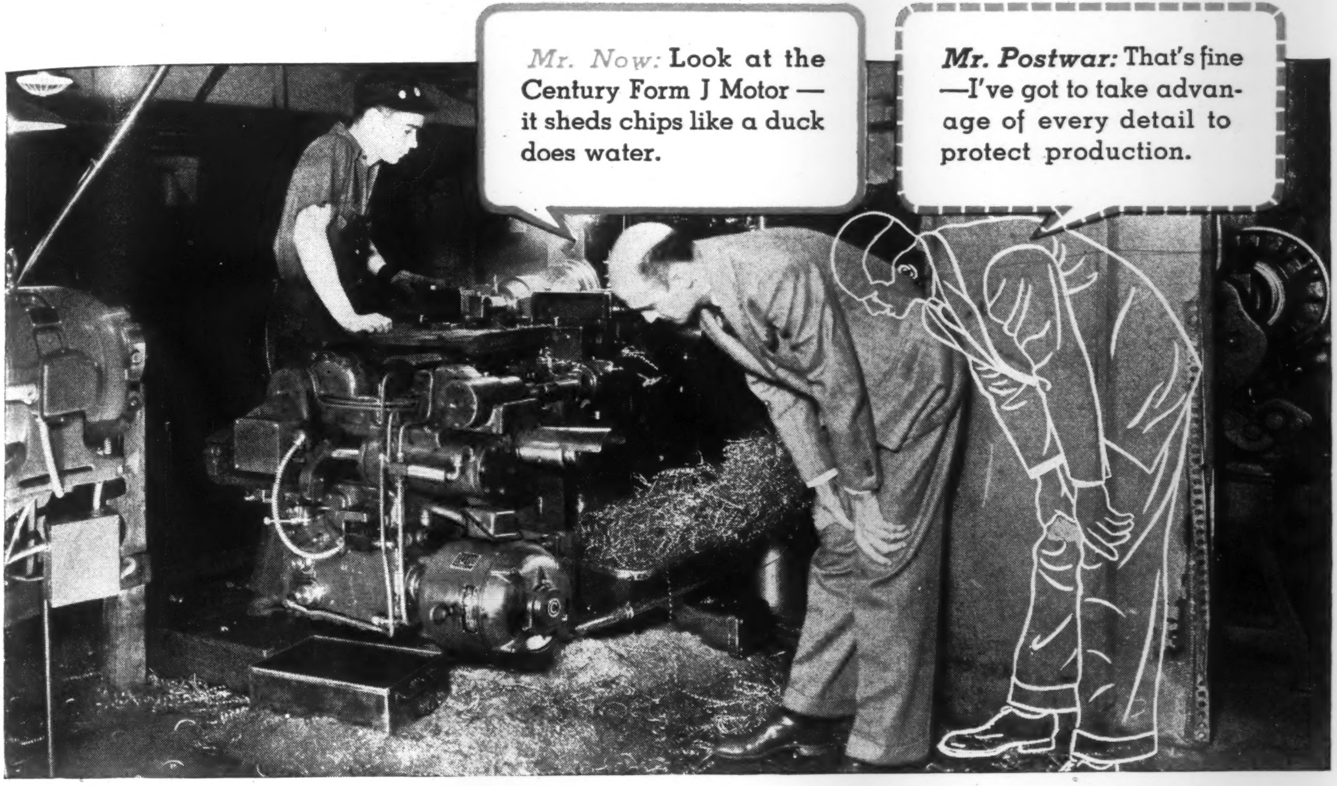
○

C. E. FRUDDEN, consulting engineer of the tractor division, Allis-Chalmers Mfg. Co., Milwaukee, is now back with the company after having served with the War Production Board for nearly a year.

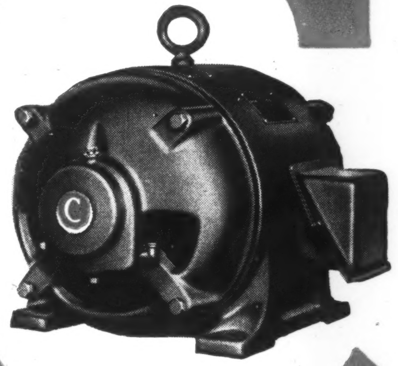
○

G. M. BELLANCA has joined Higgins Industries Inc., New Orleans, La., as consulting aeronautical engineer and

Take a Look at TOMORROW—*Today!*


Mr. Now: Look at the Century Form J Motor — it sheds chips like a duck does water.
Mr. Postwar: That's fine —I've got to take advantage of every detail to protect production.

Greater Protection



Century Form J Motor

320

Developed especially to assure greater protection than the usual open motor, Century Form J, General Purpose Motors have a protecting hood over the upper half of the motor, preventing falling solids or dripping water from entering vital motor parts. This is particularly advantageous when motors are installed *below the work level* on machine tools — constantly exposed to falling chips of metal.

This extra protection is made possible by Century's scientifically designed ventilation system which gives positive cooling to motor windings and bearings and assures rapid heat dissipation.

This is only one example of the improved Century Motors being developed under the demands of Wartime production. Now and after Victory, Century anticipates — and meets — *your* needs.

CENTURY ELECTRIC COMPANY
1806 Pine Street St. Louis, Missouri
Offices and Stock Points in Principal Cities

Century MOTORS

up to 600 horsepower

One of the Largest EXCLUSIVE Motor and Generator Manufacturers in the World

BROTHER, THIS IS WAR

War Drawings Are Extremely Valuable! Assure Their Permanence—Use

ARKWRIGHT TRACING CLOTHS!

Here are two advantages of Arkwright Tracing Cloths—especially important if you're producing war drawings! First, Arkwright Tracing Cloths don't become brittle or opaque—don't lose the high transparency needed to make sharp, accurate transfers—even when filed away for years. Second, Arkwright Tracing Cloths can be run through blueprint machines time after time without tearing, fraying, or curling. Safeguard all war drawings—use Arkwright Tracing Cloths. Arkwright Finishing Company, Providence, R. I.

Arkwright
PENCIL TRACING CLOTH
Prudence
TRACING CLOTH
Matsurf
PENCIL TRACING CLOTH
FOR PENCIL OR INK
Arkwright
PENCIL CLOTH WHITE
Arkwright
TRACING CLOTH

Arkwright

TRACING CLOTHS

AMERICA'S STANDARD FOR OVER 20 YEARS

designer. He is chairman of the board, Bellanca Aircraft Corp., New Castle, Del.

ARTHUR W. F. GREEN, formerly materials engineer for Pratt & Whitney Aircraft, Division of United Aircraft Corp., East Hartford, Conn., has been appointed materials engineer administrator over the heat treating and plating divisions of N. A. Woodworth Co., Ferndale, Mich.

JAY A. BOLT, previously assistant professor of aeronautical engineering at the University of Notre Dame, has become connected with the Stromberg Aircraft Carburetor section of the Bendix Aviation Corp. as engineer in charge of special projects.

WILLIAM J. TELL has joined the Cadillac Motor Car division, General Motors Sales Corp., Detroit, in the capacity of executive engineer. He had previously been chief engineer of the Eastern Aircraft division, General Motors Corp., Linden, N. J.

FRANK J. HAHN has been transferred from the Pratt & Whitney Aircraft Corp. in East Hartford, Conn., where he was experimental test engineer, to the company's plant in Kansas City, Mo., in the capacity of chief test engineer.

HAROLD CAMINEZ has become consulting engineer for the Aircraft Screw Products Co. Inc., Long Island City, N. Y.

PERCY C. SMITH was recently elected a vice president of the Arrow-Hart and Hegeman Electric Co., Hartford, Conn. He began with the company in 1916, and later was made head of the industrial division in charge of development and sales of industrial apparatus. In 1937, he was in charge of the engineering, testing, tool and drafting departments, with the title of director of engineering.

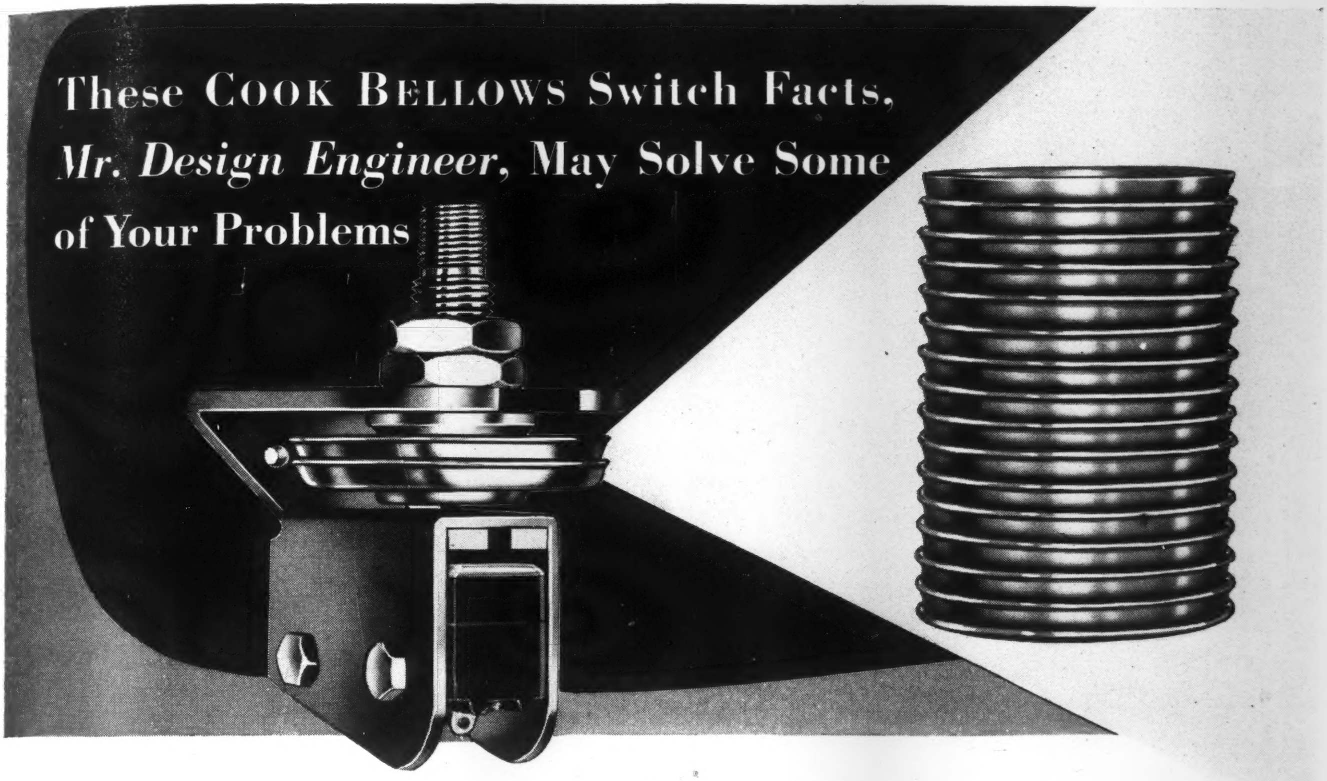
F. DELORENZO has recently become associated with the Brown Fintube Co., Elyria, O., as manager of the heat transfer department. A graduate of Massachusetts Institute of Technology, Mr. DeLorenzo since 1936 has been design engineer for Foster Wheeler Corp. in the oil division, specializing in heat transfer and flows of fluids.

ROGER M. WISE, formerly chief engineer, has been made director of engineering for Sylvania Electric Products Inc. This is a new functional designation within the company's activities.

W. E. HIRTENSTEINER has been appointed executive vice president of Interstate Aircraft & Engineering Corp. WALTER A. HITE, vice president in charge of engineering, has been elected to the board of directors of the corporation.

JOHN L. VAILL has now formed his own company which will specialize in the design and manufacture of special machinery for the aircraft industry and its subcontractors. Mr. Vaill had been with the American Metal Hose branch

These COOK BELLOWS Switch Facts, *Mr. Design Engineer,* May Solve Some of Your Problems



It Is "Tailor-Made" To Do The Job You Specify

The Cook Bellows Switch is "tailor-made" to meet your design specifications . . . It can be designed to operate on pressure or vacuum, with pressures as low as one ounce and higher than 100 pounds; with vacuums as low as ¼" or complete vacuums.

Cook Bellows Switches can be provided with normally open or normally closed contacts. They are provided with quick make and close contacts rated at 10 amperes, 110 volts; 5 amperes, 20 volts . . . come in single pole, single throw, or single pole, double throw.

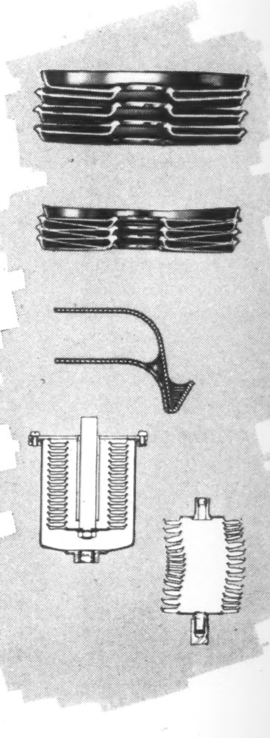
Cook Bellows Switches are corrosion resisting, withstand severe shock and vibration, are not affected by temperature variations, withstand a 10 G. test. They can be mounted in any position without affecting the operating characteristics of the switch.

Various sized bellows can be supplied, depending on the job to be handled. Cook Bellows Switches will be supplied complete with all fittings or in skeleton models to suit individual requirements. Adjustments can be supplied on these switches to compensate for ranges in field applications.

The Cook Bellows Switch can be operated with air, gases, or fluids . . . The switching mechanism, which the "Spring-Life" Bellows unit will easily outlast, can be replaced without effort.

Send us your specifications and we shall be glad to give you complete data applying to your particular problem.

This is the *"Spring-Life"* Principle



The "Spring-Life" principle employs a patented method of construction in which diaphragms or flanges are joined alternately at their inner and outer peripheries. Each flange is characterized by a flat section with radial corrugations and cupped inside and outside edges.

Radial corrugations in each flat section provide greater stiffness or greater resiliency as desired, add materially to the life of the bellows, and permit closer control of flexibility.

Flexure in the assembled bellows takes place at both the inside and outside curved section when pressure is applied.

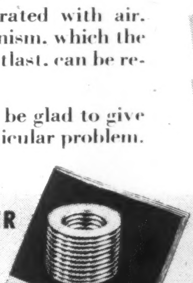
Diaphragms are lock-seamed and solder is flowed into the groove, eliminating air bubbles and assuring strength.

The action of "Spring-Life" construction is like a long spring under tension. Therefore, when pressure is applied to the outside, it is necessary to mount the bellows in a cup as shown.

THIS BOOK GIVES YOU THE ANSWER

Send for it ➡

This book explains the theory of "Spring-Life" construction, its advantages, and data for specifying your requirements for out-of-the-ordinary bellows applications. We will send you as many copies as your engineering department may desire.



COOK ELECTRIC COMPANY

2700 SOUTHPORT AVE., CHICAGO, ILL.

USE FELT IT IS READILY AVAILABLE!

AMPLE SUPPLIES OF RAW MATERIALS

1. The types of wool used for the manufacture of wool FELT are in a very favorable position. For the most part these wools are *not* usable for woven textiles.

EFFICIENT MANUFACTURING FACILITIES

2. Modern equipment and laboratory control "all the way" produces FELTS to *precise* specifications for hundreds of vital needs of our Armed forces.

SCIENTIFIC PRODUCTION METHODS

3. Millions of washers and intricate parts with narrow tolerances are die cut with precision by high speed presses.

4. FELT is replacing critical materials such as rubber, cork and leather, because of the above facts *plus* the Industry's "will to serve" for Victory.

TELL US your requirements. We will send samples for inspection. Consultants are available for personal advice. We like to help.

American Felt Company

TRADE MARK

General Offices: GLENVILLE, CONN.

New York; Boston; Chicago; Detroit; Philadelphia; St. Louis
Cleveland; Los Angeles; San Francisco; Dallas; Seattle

PRODUCERS OF FINEST QUALITY PARTS FOR OIL RETAINERS, WICKS, GREASE RETAINERS, DUST EXCLUDERS, GASKETS, PACKING FELTS, VIBRATION ISOLATING FELTS AND INSULATING FELTS

of the American Brass Co. for eleven years, serving as head of the engineering department for the past six years.

George W. Codrington, vice president of General Motors Corp., in charge of the Cleveland diesel engine division, has been elected president of the National Association of Engine and Boat Manufacturers.

Ralph W. Hisey, vice president, Osborn Mfg. Co., has been elected president of Foundry Equipment Manufacturers association. He formerly served the association as a director.

Rex B. Beisel, chief engineer, has been named acting general manager of the Chance-Vought Aircraft division.

Harry D. Smith, has been appointed first vice president and executive engineer of Globe Hoist Co., with headquarters in Philadelphia.

Ray A. Penny has been advanced to chief engineer from assistant chief engineer of St. Paul Hydraulic Hoist Co., Minneapolis.

George H. Clark was recently elected vice president in charge of engineering, Formica Insulation Co., Cincinnati. Mr. Clark has been with the company for eighteen years and is a well known laminated plastics engineer. Another appointment by the company is that of R. W. Lytle, with the company twenty years, to vice president in charge of special engineering, supervising automotive and aircraft engineering.

Bernard R. Schneider, formerly assistant chief engineer of Champlain Corp., has joined the Chicago Pneumatic Tool Co., Hydraulic division, Garfield, N. J., as chief engineer. Anthony Kes, also previously connected with the Champlain company, has been appointed assistant chief engineer of the Chicago Pneumatic Tool Co., Garfield, N. J.

William Loren Batt, vice-chairman of the War Production Board and president of S K F Industries Inc., has been awarded the Bok award "for his service to the Nation in leading industrial mobilization of the war" and "as a citizen who performed the most distinguished service for Philadelphia in 1942."

R. E. Zimmerman was recently re-elected president of the American Standards association. He is vice president of the U. S. Steel Corp.

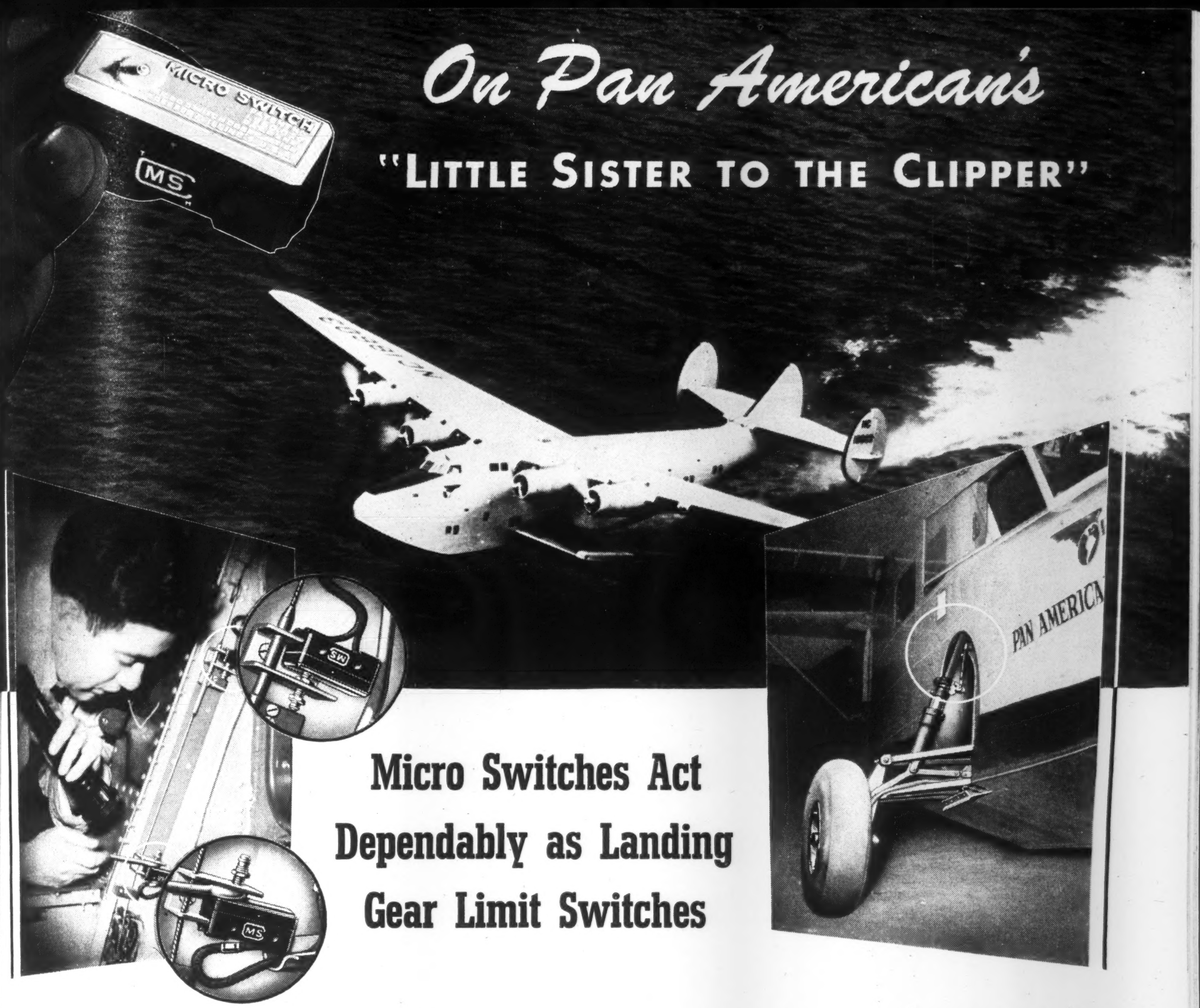
A. H. B. Jeffords has been made vice president of Trundell Engineering Co., Cleveland, and will specialize on war production rules and requirements.

Robert K. Kulp, formerly associated with the Steel and Tube division, Timken Roller Bearing Co., as research metallurgist, has been appointed director of research by Jessop Steel Co., Washington, Pa.

John W. Horner, experimental research engineer, has joined Guiberson Diesel Engine Co. as a member of its development staff.

On Pan American's

"LITTLE SISTER TO THE CLIPPER"



Micro Switches Act Dependably as Landing Gear Limit Switches

Illustrated here is one of the Pan American Airways' huge 42½ ton Transocean Clippers. In the inserts are shown the landing gear and the Micro Switches which are used as limit switches on Pan American's Grumman Widgeon trainers. This plane is often referred to as the "Little Sister to the Clipper."

These trainers are used for training the intrepid pilots who fly the giant Clippers over the seven seas. Because of the nature of the work performed, it is obvious that every precaution must be taken, every contingency provided for. That is why Pan American depends on the rugged dependability of Micro Switch.

Thumb-size and feather-light, Micro Switch is amazingly rugged, resists vibration, and requires no leveling. It operates precisely at the same point for millions of operations with lightning-fast contact action. It is accurately built to exact standards from precisely made parts. Its performance characteristics can be changed to meet functional requirements.

Micro Switches are used to perform many different functions in aircraft. Special brackets, actuators, and aluminum housings are available for this purpose. For heavy duty service such as machine tools, there are Micro Switches enclosed in steel which can be sealed against dirt, dust, water, oil, metal chips and other foreign particles.

All Micro Switches can be supplied with a variety of actuators to meet all needs. Micro Switches operate on pressures as low as one ounce and movements as low as .0002". Micro Switch is listed by Underwriters' Laboratories with ratings of 1200 V.A. loads, from 125 to 600 volts A.C.

Every engineer should have a copy of Micro Switch Handbook Catalogs which tell and illustrate the principles and applications. Handbook Catalog Number 60 deals with Micro Switch in general, and Number 70 is written specifically for aircraft applications.

Micro Switch Corporation, Freeport, Illinois
Branches: 43 E. Ohio St., Chicago • 11 Park Place, New York City
Sales and Engineering Offices: Boston • Hartford • Los Angeles

The trademark MICRO SWITCH is our property and identifies switches made by Micro Switch Corporation

© 1943

MICRO SWITCH

Made Only By Micro Switch Corporation . . . Freeport, Illinois

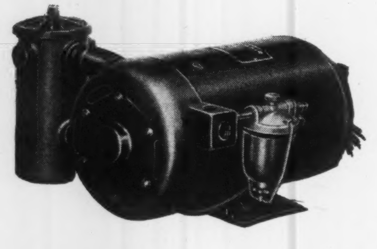
FOR VACUUM
OR PRESSURE PUMPS

MORE Power
per cubic inch—
with LESS PARTS
to wear out!

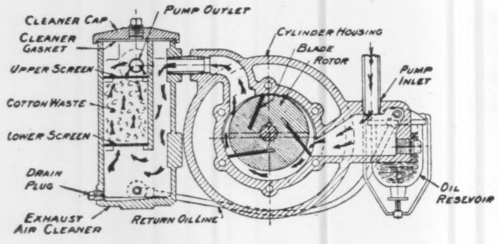
NJM CORP.

MOTOAIR

TOPS THEM ALL!



It's *modern!* Made with dependable motor and pump in ONE integral unit, with a saving in metal that means a saving in cost and elimination of the cost of operation.



NO DRIVES
NO BELTS
NO GEARS
NO GUARDS
●
NO PULSATION

Free air volume up to 35 cu. ft. per minute, Vacuum up to 25 inches of mercury. A visible *improved* lubrication system. Can be used in wall, ceiling or normal mounting.

A dependable COMPACT Accessory
—a preferred independent unit

Hundreds of these dependable Pumps are being used by Government and Industrial Plants, as stationary or portable units.

Ask for a Demonstration:

NEW JERSEY MACHINE
CORPORATION
15th & Willow Ave., Hoboken, N. J.
Chicago Office
325 W. Huron St.

NOTEWORTHY PATENTS

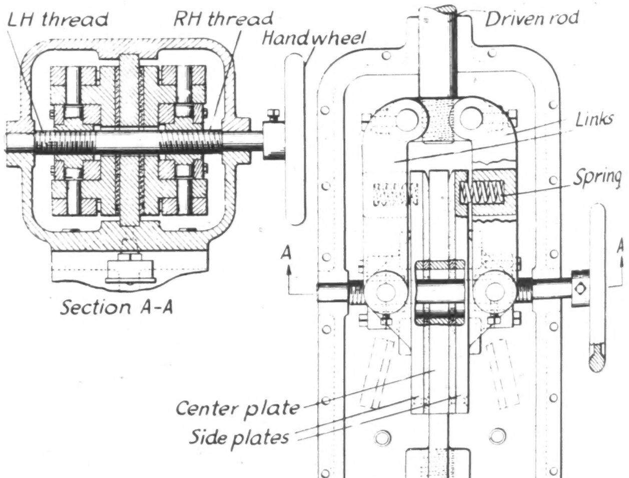
Clutch Transmits Vibrating Motion

VIBRATORY shaking systems such as are used on paper machines pose a starting problem, especially when it is desired to engage the shaking system with the driving motor after the motor has come up to resonant speed. A clutch mechanism covered by patent 2,303,407, assigned to Submarine Signal Co., offers a solution which permits variation of the amplitude of the vibratory system while coupled to a constant amplitude driving device.

Driving rod is reciprocated with constant amplitude by a motor connected through a crank or eccentric mechanism. The driven rod actuates the shaking system and may have variable amplitude. As shown in the illustration, motion is transmitted from the driving to the driven rod through a flat plate clutch. Central plate is fixed to the driving rod and slides in channels cut in the housing. Side plates, provided with friction shoes, actuate the driven rod through a pair of forked links with pin connections.

Pressure necessary for the transmission of motion is applied through two threaded blocks mounted on a shaft with right-hand and left-hand threads. Rotation of the shaft by means of the handwheel causes the blocks to press the side plates against the center plate or allows them to separate, depending on the direction of rotation.

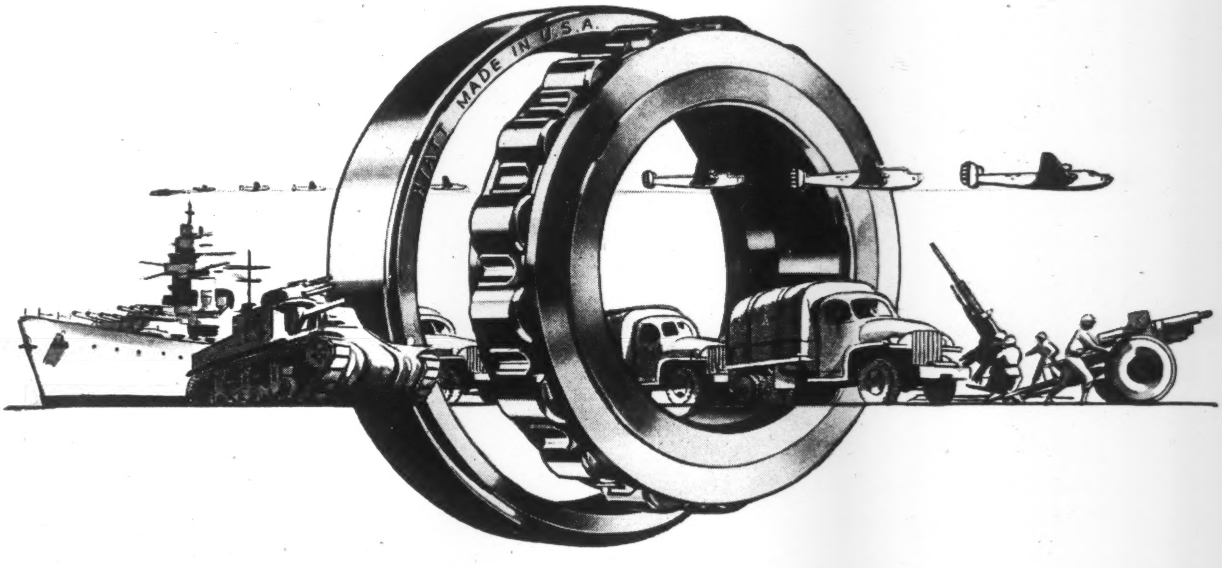
A pair of helical compression springs between the side plates and links holds the shoes in contact with the central plate. When the blocks are pulled apart the spring pressure holds the friction shoes in contact at one end only, the other ends tilting into the position indicated by broken lines on the plan view. Because of the light contact pressure in this position the transmitted force and the ampli-



Amplitude of reciprocating driven rod varies according to the pressure applied to the side plates

Keeping Them Rolling—

Our Job Yesterday, TODAY and Tomorrow!


HYATT MADE IN U.S.A.

TODAY the heavily loaded shafts, gears and wheels of vital war equipment turning on Hyatt Roller Bearings, are well protected against shocks, excessive wear and breakdowns.

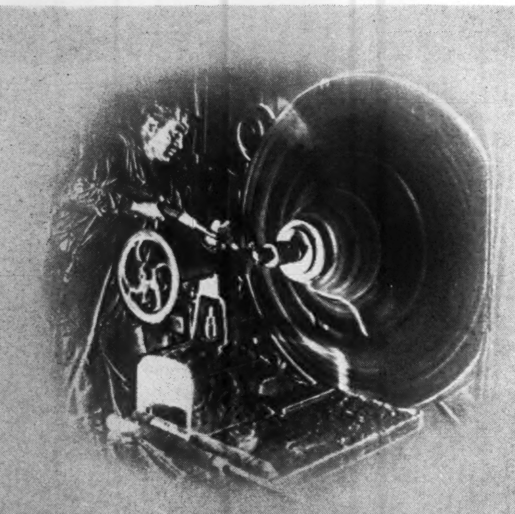
And other smooth rolling Hyatts, of the same microscopic accuracy and unyielding stamina, are serving round-the-clock in the machines which help build mighty guns and planes and tanks and ships.

Prolonging machine life . . . keeping equipment going . . . has been a job done well by Hyatts for the past fifty years. And after this war's won, there will be many more industrial, agricultural and transportation bearing applications in which Hyatts will continue to serve and save for another half century.

Is there any way we can help you now? Hyatt Bearings Division, General Motors Corporation, Harrrison, N. J.

ARMY E NAVY

HYATT ROLLER BEARINGS



The VERSATILITY of Metal Spinning *will amaze you!*

Do you know: that Spincraft's Metal Spinning technique enables you to get a tiny quarter inch diameter thimble or a huge sixty odd inch diameter aircraft engine cowl in a few days time?

This quick transition of a blueprinted idea to a finished product is but one phase of metal spinning's amazing versatility.

Spincraft is compiling a bookful of equally important examples. You will need this valuable data—get on the mailing list by writing now for the latest Spincraft bulletin, "Why Metal Spinning is so important to Industry Today."

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"SKILL WILL DO IT"
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tude of the driven rod are small. As the blocks move inward the shoes are pressed with greater force against the center plate, providing a gradually increasing contact accompanied by increasing amplitude of the driven rod until the members are tightly clamped together and move with equal amplitude.

Reversing Drive Uses Fluid Couplings

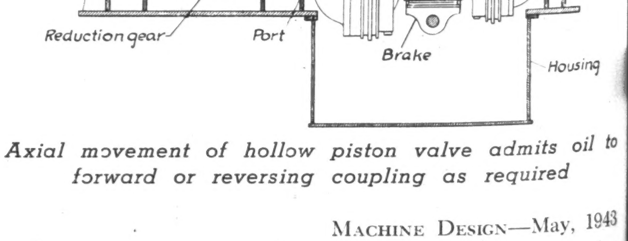
A REVERSING drive suitable for use with nonreversible engines or motors of considerable size is covered by patent 2,301,294, recently assigned to General Motors Corp. Characteristics of the drive, which is particularly adaptable to marine propulsion systems and similar applications, include quick reversing without the need for stopping the driving engine or motor.

Principal features of the design are shown in the illustration. Driveshaft is connected to the engine at right and carries the impeller elements of two fluid couplings. Runner of the forward coupling is direct-connected to the pinion of the reduction gear. When oil is admitted to the forward coupling only, power is transmitted through this coupling from the engine to the pinion without change in direction of rotation.

Runner of the reverse coupling is attached to a bevel gear meshing with a series of bevel pinions on radial axes mounted in a frame which can be held stationary by a brake band. Also meshing with these pinions is a bevel gear attached to the runner of the forward coupling. Reverse rotation is accomplished by admitting oil to the reverse coupling only, thus driving the reverse runner and its attached bevel gear. Through the bevel pinions the forward runner is driven in the reverse direction, thus driving the reduction gear in this direction.

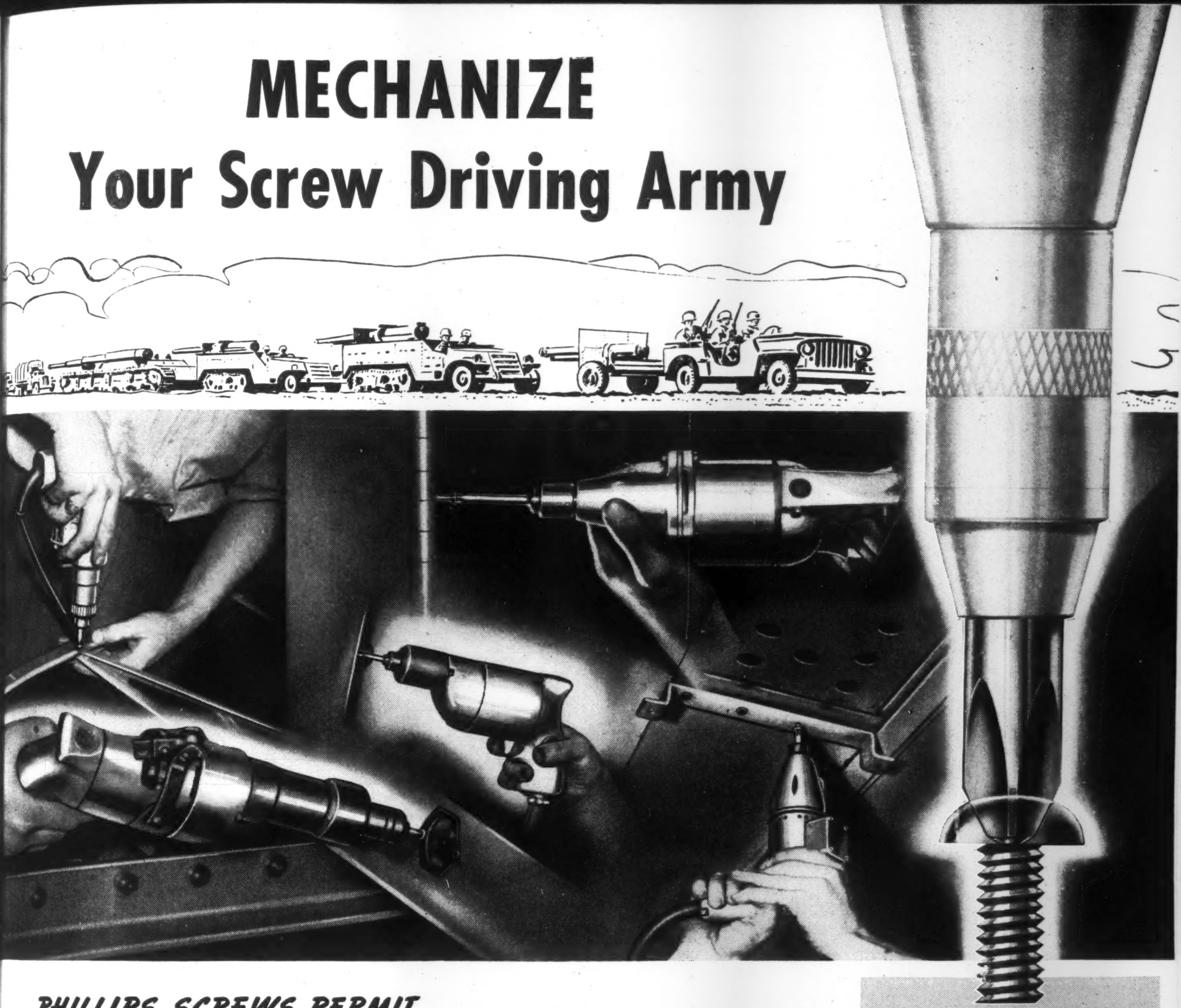
Oil admission to the couplings is controlled by a hollow piston valve fitting inside and rotating with the hollow driveshaft and pinion shaft. When in the position shown oil admitted under pressure through the inlet connection at left flows through the valve and out through ports into the forward coupling. When the valve is shifted to the right by means of the external control lever at left, the ports at the forward coupling are closed and those at the reverse coupling are opened, admitting oil.

Release of oil from the couplings is controlled by ring valves on the circumference of the runners which normally cover the dump outlets. Axial movement of the ring valve uncovers the outlets, permitting the oil to discharge into the housing which surrounds the coupling assembly.



Axial movement of hollow piston valve admits oil to forward or reversing coupling as required

MECHANIZE
Your Screw Driving Army



PHILLIPS SCREWS PERMIT FAST DRIVING METHODS!

Like our fast-moving fighting forces, your screw driving army can now be mechanized to set new speed records on the assembly line.

You can have the advantages of power or spiral driving on almost any job . . . by adopting Phillips Recessed Head Screws. Automatic centering of driving force in the Phillips Recess eliminates the driving troubles that often make fast driving methods impractical. Fumbling, wobbly starts . . . slant-driven screws . . . broken-head screws . . . dangerous skidding of driver points . . . all are forgotten problems in plants that use screws with the Phillips Recessed Head.

Even "green hands" can do fast, skilled work. Savings of 50% in driving time are common. Such man-hour savings are important to the war effort, since so many workers in the average plant are driving screws.

They cost less to use! Compare the cost of *driving* Phillips and slotted head screws. You'll find that the price of screws is a minor item in your total fastening expense . . . that it actually costs *less* to have the many advantages of the Phillips Recess in your assembly work.

KEY TO FASTENING SPEED AND ECONOMY

The Phillips Recessed Head was scientifically engineered to afford:

Fast Starting – Driver point automatically centers in the recess . . . fits snugly. Screw and driver "become one unit." Fumbling, wobbly starts are eliminated.

Faster Driving – Spiral and power driving are made practical. Driver won't slip out of recess to injure workers or spoil material. (Average time saving is 50%.)

Easier Driving – Turning power is fully utilized by automatic centering of driver in screw head. Workers maintain speed without tiring.

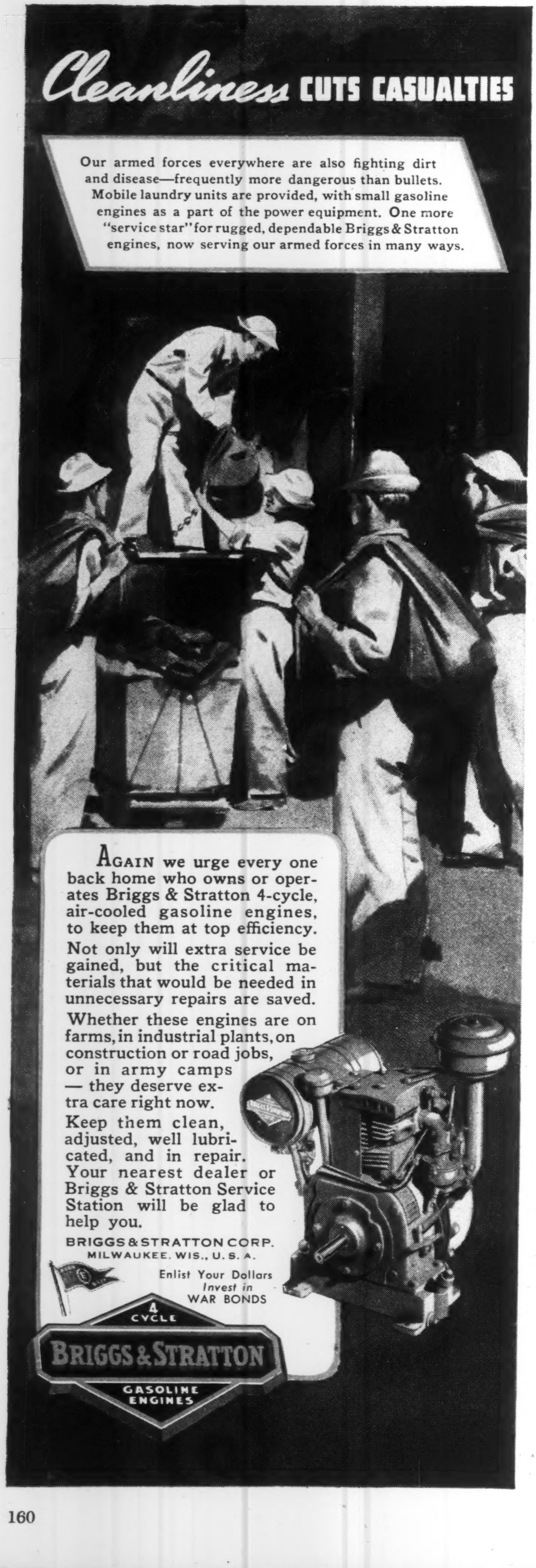
Better Fastenings – Screws are set-up uniformly tight, without burring or breaking heads. A stronger, neater job results.

PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS · MACHINE SCREWS SELF-TAPPING SCREWS · STOVE BOLTS

21 SOURCES

American Screw Co., Providence, R. I.
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
The H. M. Harper Co., Chicago, Ill.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
The Charles Parker Co., Meriden, Conn.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Reading Screw Co., Norristown, Pa.
Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterville, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.



Cleanliness CUTS CASUALTIES

Our armed forces everywhere are also fighting dirt and disease—frequently more dangerous than bullets. Mobile laundry units are provided, with small gasoline engines as a part of the power equipment. One more "service star" for rugged, dependable Briggs & Stratton engines, now serving our armed forces in many ways.

AGAIN we urge every one back home who owns or operates Briggs & Stratton 4-cycle, air-cooled gasoline engines, to keep them at top efficiency.

Not only will extra service be gained, but the critical materials that would be needed in unnecessary repairs are saved.

Whether these engines are on farms, in industrial plants, on construction or road jobs, or in army camps — they deserve extra care right now.

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DESIGN ABSTRACTS

Landing Wheel Prerotation Poses Problems

PREROTATION of airplane landing wheel tires offers a means of rubber conservation, and it would appear from the table below that it might have definite advantages. The mileage on the 17.00 x 16 tire is based on an average life of 800 hours, one landing per hour. The distance traveled on the ground per landing and takeoff, including taxiing, is estimated at 3½ miles.

Several incidental problems arise in connection with the use of prerotational devices. Quoting from a report by Henry Schippel: "Elimination of all brake drag is an absolute essential for dependable prerotation. Any vibration due to tire and wheel unbalance will be aggravated due to the longer period of high-speed tire rotation. Full rotation of tires may inject an aggravated factor into brake performance due to the addition of a load of 40,000 foot-pounds of energy on the brakes, that would otherwise be absorbed by sliding the tires on the ground. On the assumption that tread wear is proportional to the energy imparted to the tire by the ground to bring the tire and wheel up to full ground speed, we can measure the value of any given method of prerotation in terms of the ratio of energy of rotation of the tire and wheel assembly before and after contact with the ground. Since kinetic energy is proportional to the square of velocity this ratio is simply the ratio of the squares of tire tread velocities for the two conditions. Thus if the tread surface achieves one-half ground speed the ratio is .25 which would mean the elimination of only 25 per cent of tread abrasion at the moment of landing."

Comparative Tire Loadings, Deflections and Mileages

Size	Type	Ply	Recommended load (lb.)	Inflation pressure (psi)	Allowable deflection (per cent)	Av. life (miles)	Rubber lost per mile (lb.)
6.00 x 16	Pass. car	4	915	28	16	25,000	.00010
9.00 x 20	Truck	10	3,450	65	13	50,000	.00025
17.00 x 16	Airplane	10	13,500	48	35	2,800	.00570

The Boeing Aircraft Co. recently completed a test on prerotation using vanes. The vanes proved satisfactory in producing a high enough speed to cause a considerable reduction in the required acceleration upon landing. No screeching or scuffing of the tire could be heard during initial wheel contact with the ground.

Other ideas for prerotating the landing wheel tires include wind motor drive, flexible shaft power takeoff from motor, and motor-driven wheels. The high cost per year of hauling added weight ($20.00 per pound) has held back development of these ideas.

To be worthy of consideration prerotation should show an improvement of 20 per cent in tire life. With vaned

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Bearing Problems
...WITH MICARTA BEARINGS
DESIGNED AND ENGINEERED
FOR YOUR PRODUCT
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This is another job
for Micarta
C.E.S.

If you have a bearing problem, bring it to Westinghouse. Skilled Micarta engineers will be glad to study your product and to analyze its applications. And they will give you the benefit of 35 years' experience with industrial plastics.

This experience is particularly extensive with respect to applications where lubrication by water is advantageous . . .

FOR EXAMPLE, in more than 3,000 steel mill installations, heavy-duty Micarta bearings are giving 10 to 15 times longer life—in one case, 100 times longer life.

ON FIGHTING SHIPS AND CARGO VESSELS, Marine Micarta propeller shaft bearings and rudder stock bushings last many times longer than wood.

AND HUNDREDS OF THOUSANDS of Micarta sleeve bearings are in use in other industries where dependability is vital.

In these applications Micarta has taken over and is serving better. Softer than metal, Micarta provides a highly polished bearing surface. Whether lubricated with water, grease or oil, its coefficient of friction is low.

Micarta bearings are available for high or low-speed applications . . . for water, oil or grease lubrication . . . or graphitized for self-lubrication. When the job calls for bearings, be sure you have all the facts about Micarta. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania.

J-06336

TYPICAL MICARTA TOUGH JOBS IN WAR APPLICATIONS

- Aircraft structural parts
- Industrial gears
- Instrument panels
- Steel mill bearings
- Thrust washers
- Marine bearings
- Protective helmet liners
- Aircraft control pulleys
- Bus supports
- Fuse mountings
- Insulating washers

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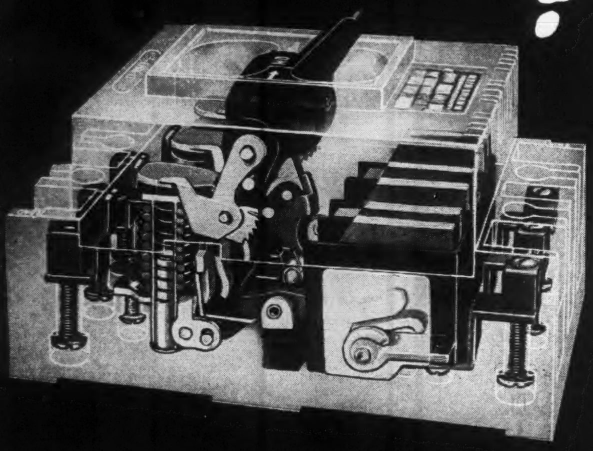
PLANTS IN 25 CITIES OFFICES EVERYWHERE

Micarta *The* INDUSTRIAL PLASTIC

Circuit Protection?



Put it up to

HEINEMANN
MAGNETIC
CIRCUIT BREAKERS

These breakers provide the ideal combination of time delay (to prevent nuisance trips on harmless starting surges) and high speed interruption of short circuits. The time delay may be matched to circuit characteristics by use of different hydraulic media. Ampere ratings between 50 milliamperes and 50 amperes may be matched accurately to the load by proper wire size and ampere turns on the magnet coil. 5,000 ampere short circuit interrupting capacity is accomplished by magnetic blowout action.

HEINEMANN CIRCUIT BREAKER CO.
Subsidiary of Heinemann Electric Co.
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113 PLUM STREET TRENTON, N. J.

tires costing 15 per cent more than regular tires and weighing 10 pounds more per plane the savings on tire replacements are more than offset by the cost of hauling the added weight. The weight of any mechanical prerotating device should not exceed 10 pounds per plane to be economical, assuming a 20 per cent improvement could be shown.—*From a paper by C. R. Mason and W. H. Elliott presented at the National Aeronautic meeting of the S.A.E. in New York, April 8-9.*

Looking Ahead in Plastics

IN COMBINATION with metals, plastics will assume a prominent role in postwar activities. I look for the day when every metalworking establishment will have a plastics division. There are many industrial applications where these two materials can be designed in a complementary rather than competitive manner. Metal castings in molded plastics, resin-bonded metal fillers, metal-plated plastics, and plastic-sealed metal castings—these are a few of the well-known combinations. Looking further, we will find plastics adhesives for metal parts, wood and plastic laminates structurally reinforced with metal, and powder metallurgy borrowing the production techniques of plastics. I would recommend that plastics molders familiarize themselves with powder metallurgy, for therein is an industry in which they can make outstanding contributions.

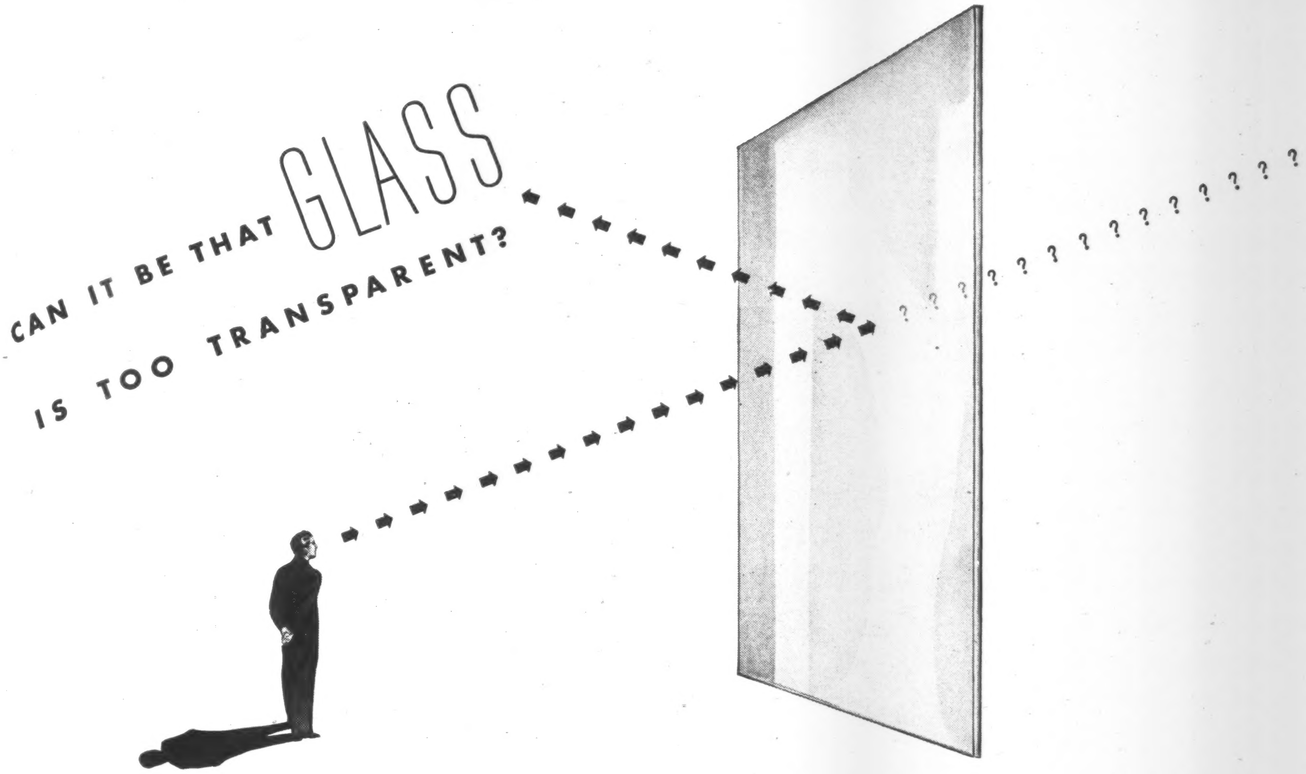
Postwar plastic materials may differ appreciably from the present outstanding types. We undoubtedly will hear much more about copolymers and interpolymers, as well as mixed esters, largely because present research efforts are directed toward finding new and more economic sources of raw materials. Further, plastics and synthetic rubbers are demonstrating complementary qualities and there is every reason to hope for continuance of the combined efforts of the plastics and rubber industry after the war.—*From a recent talk before the Society of the Plastics Industry by John Delmonte, Technical Director, Plastics Industries Technical Institute.*

Splice Keeps 'Em Turning

RATHER than replace old belt-driven machine tools forced into service by demands of war production, Westinghouse attempted to get the most out of these machines by improving existing drives. A method of splicing solid woven cotton belting perfected by our engineers provides a satisfactory flat belt drive using no critical materials. Cementing of the belting is done without special tools or expensive equipment and can be carried out at the machine where the belt is to be used. This permits the employment of cemented belting having the advantages of endless belts on machinery and equipment so constructed that endless belts cannot ordinarily be used.

For power transmission purposes a special belt using an "inner bound" weave is required. This type of weave permits high flexibility and prevents the plies from separating should the surface threads break or become worn. Actual splicing procedure is somewhat similar to the method

(*Continued on Page* 168)



MAYBE SO, MAYBE SO. It is a fact that everybody looks *through* glass. You always have and you always will. Perhaps because it is so transparent, you've really never stopped to think about its other properties.

Now we ask you to look at the properties of glass . . . a good, long look . . . a look with your imagination.

You discover one of the most versatile materials in the world. These sparkling sheets we make have many amazing qualities, in addition to transparency, which make glass a better material for scores of everyday uses.

Chemically, glass is the most stable of all materials excepting the noble metals. It will not rot, oxidize, or disintegrate.

Dimensionally, glass is more stable, too. It keeps its shape. The coefficient of expansion is lower than practically any other material.

The surface of glass is among the hardest in the world. It is nonporous; will not absorb odors or moisture. It is more acid-resistant than any structural material. It offers unusual resistance to abrasion. It can be coated, polished, or etched. In large sheets, it can be made smoother than any other material. Its weathering qualities are unequaled.

Glass is *strong*. Make no mistake on that point. A square foot, quarter-inch sheet, the way we temper it, will withstand a pressure of 60 pounds per square inch. Double the thickness and you quadruple the strength. Our tempered glass has a modulus of rupture of 30,000 pounds per square inch, and it will withstand a thermal shock of 400 degrees Fahrenheit. Actually, tempered glass is stronger than many metals.

There are many more unusual physical and chemical properties of glass . . . properties found in combination in no other material. L·O·F can help you sort them out, team them up, practically any way you want. You can have the final product in flat sheets or bent shapes, laminated or fabricated with another material. You can have it in multiple units, or with metal or plastic collar.

Won't you write us about any possible use of glass that may appeal to you, no matter how revolutionary or unusual? That's the way to really find out. Libbey·Owens·Ford Glass Company, 1153 Nicholas Bldg., Toledo, Ohio.

Destructible?

Wood-Metal-Plastics-Glass. No material is indestructible. However, barring unseen conditions, no material will fail on a job in which it has been properly specified and engineered. When our application engineers say "Yes", you can be sure about glass.

L O F

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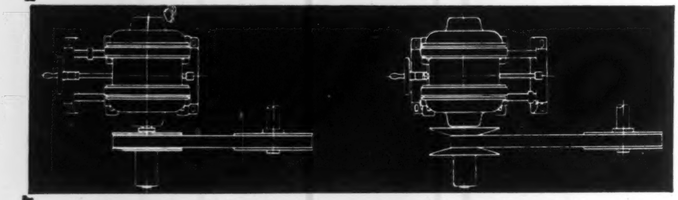
A GREAT NAME IN *Glass*

No Design Changes Necessary
in your
Machine Drives
with
IDEAL
VARIABLE
SPEED

CHANGE SPEEDS WHILE MACHINE IS RUNNING!



Maximum Speed Position. Motor close to driven sheave. V-Belt at largest pitch diameter.

Minimum Speed Position. Motor away from the driven sheave. Pulley open to smallest pitch diameter.

PROVIDES the IDEAL SPEED FOR EACH JOB

TO MEET ALL WAR PRODUCTION AND PEACE TIME REQUIREMENTS.

Give the machines you build greater versatility. Equip them to change speeds to suit different jobs—different operators—different materials. Install inexpensive IDEAL Variable Speed. Simple, Compact, easy to adapt to your designs. Easy to install; mounts directly to motor shaft.

By merely turning a hand wheel your machine can be speeded up or slowed down instantly, giving it an infinite range of speed, up to 3 to 1 ratio.

IDEAL Speed is available for V-Belt and wide V-Belt: Sizes up to 8 H.P.

FEATURES Of IDEAL Variable Speed Pulleys

- Belt faces have full contact at all pitch diameters, due to curved pulley faces.
- Belt always runs in alignment, as both halves of pulley move.
- Compact; Light in weight; perfectly balanced.
- Full rated H.P. regardless of load conditions.
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TRANSMISSION HANDBOOK

A 52-page book full of new transmission ideas. Gives detailed technical data on Variable Speed Control. Equipment; Engineering information; Applications, how installed. Send for your copy today!

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(*Continued from Page* 162)

used in splicing leather and rubber belts. The belt is first cut to length, allowing for the splice and deducting for stretch. The ends are tapered to a feather edge, each ply being step-cut. Next the ends are prime coated with a solvent and cement solution. After drying (5 to 15 minutes), a sheet of cement which has been immersed in solvent is placed between the ends of the splice and the belt is then securely clamped and allowed to dry.

To save time on the most critical machines, belts cut to length with ends tapered are carried in stock. Temporary, mechanically fastened belts can be used while the new cemented belting is being prepared.—*From paper by R. W. Mallick, Headquarters Manufacturing Engineer, Westinghouse Electric & Mfg. Co., at the recent semiannual meeting of the American Society of Tool Engineers in Milwaukee.*

Applying High-Frequency Induction Heating

INDUCTION heating units for industrial applications are either of the low or high-frequency type. Lower frequencies are about 9,600 cycles, as compared with frequencies of 300,000 cycles, or more, with spark-gap and oscillator-type units.

With the use of high-frequency current, heat can be inducted to a predetermined area of a metal part requiring localized hardening, thus eliminating the expens heating the entire part. Likewise, the heat can be trolled to the depth desired, even to the point of heating certain small types of parts throughout, in which case the core or center-section has a tendency to heat by conduction from the outer surface which, in turn, is heated by induction.

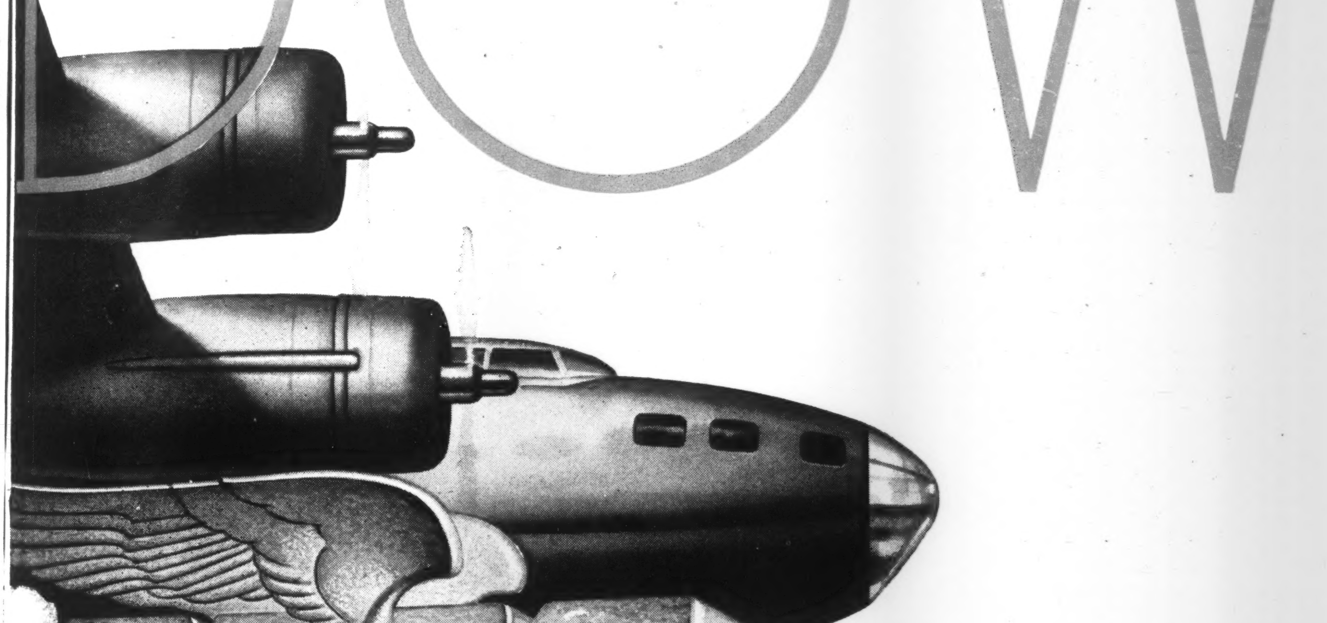
Another outstanding advantage of high-frequency heating is that parts of irregular shape, such as cams can be heated uniformly around the surface, if the variation in contour is not too severe. For example, in hardening a gear with medium-pitch teeth the heat pattern very definitely follows the contour of the tooth so that hardening can be confined to the wearing surfaces without impairing the toughness of the inner portion.

Deformation Is Negligible

With the induction-hardening process, a steel with a carbon range of .40 to .50 is used; heating is localized to the area to be hardened, without any appreciable effect on the remainder of the part; then the heated surface is quenched as required. Practically no scale is formed during heating. Warpage and deformation are exceptionally slight and in most cases do not exist; drawing becomes unnecessary because the entire part has not been subjected to heat, thus precluding internal strains. Since the hardening cycle of a high-frequency heating unit is controlled by an automatic timer, it is possible to vary the hardness of a part, one way or another as may be desired, by a slight change in the heating and quenching time cycle.

Generally speaking, most manufacturing-type steels can be hardened by high-frequency induction heating, providing the carbon content is sufficient to produce hardness by quenching. While steel having a .40 carbon is satisfac-

DOW



DOWMETAL

Dow, pioneer in the manufacture of magnesium, is one of the world's largest producers. From sea water and Michigan brine pours this weight-saving metal—moving through Dow's mills and foundries—transformed into castings, forgings, sheet and extrusions—then converted to mighty weapons of war.

Today, all production is allocated to war needs. But Dow designers are studying magnesium's wider applications in such fields as transportation, machinery, portable tools, appliances for the home—in fact, wherever light metal is essential.

THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

MAGNESIUM

PRODUCER SINCE 1916

INGOT · CASTINGS · FORGINGS · SHEET · STRIP · PLATE · EXTRUSIONS

Will Peace Come In Our Time?

Most certainly it will—and sooner than you may expect! With it will come the crucial test of whether or not American industry can convert as efficiently to peace as it has to war. From our extensive relations with hundreds of varied manufacturers we know of scores of amazing new products that only await the message of peace to come into being. Everyone looking ahead to that great day can even now count on the assistance of the Weatherhead plants which are producing scores of vital parts for planes, tanks, ships, trucks and munitions at the rate of *millions every day!*

Look Ahead with
Weatherhead
THE WEATHERHEAD CO., CLEVELAND, OHIO
Manufacturers of vital parts for the automotive, aviation, refrigeration and other key industries.

Plants: Cleveland, Columbia City, Ind., Los Angeles
Canada—St. Thomas, Ontario

tory for high-frequency hardening, it must be remembered that carbon has more influence in hardening than the addition of alloys. Although a steel with a carbon content of .35 can be successfully induction hardened, one with higher carbon is preferable, especially since the hardness can be controlled by means of timing as has already been explained. A very practical water-quenching steel for induction hardening is X1340, now SAE 1141. Because of the presence of manganese and sulphur in this grade of steel, it has excellent machining qualities, better than either SAE 1040 or 1045, and as far as can be determined the manganese and sulphur do not have any effect on hardenability with induction heating.

Ideal for Machine Parts

An ideal steel for high-frequency induction hardening applications which can well be visioned as a general all-purpose steel, would be an X1350, or perhaps X1360. With good machinability and with suitable response to induction hardening, as it no doubt would possess, this steel could well fill the requirements for a broad range of machine parts in many industries.

Induction heating will result in new engineering principles and basic changes in materials for certain types of products. Less expensive designs will be made more practical, and critical materials will give way to the simpler steels, which are easier to obtain and process. When the full possibilities of induction heating and hardening are realized, fewer steels will be required for the usual variety of parts made in manufacturing plants so that small inventories will result.—*From a paper by Frank W. Curtis, Chief Engineer, Van Norman Machine Tool Co., presented at the recent Westinghouse Machine Tool Forum.*

Represents Hardenability of Steels

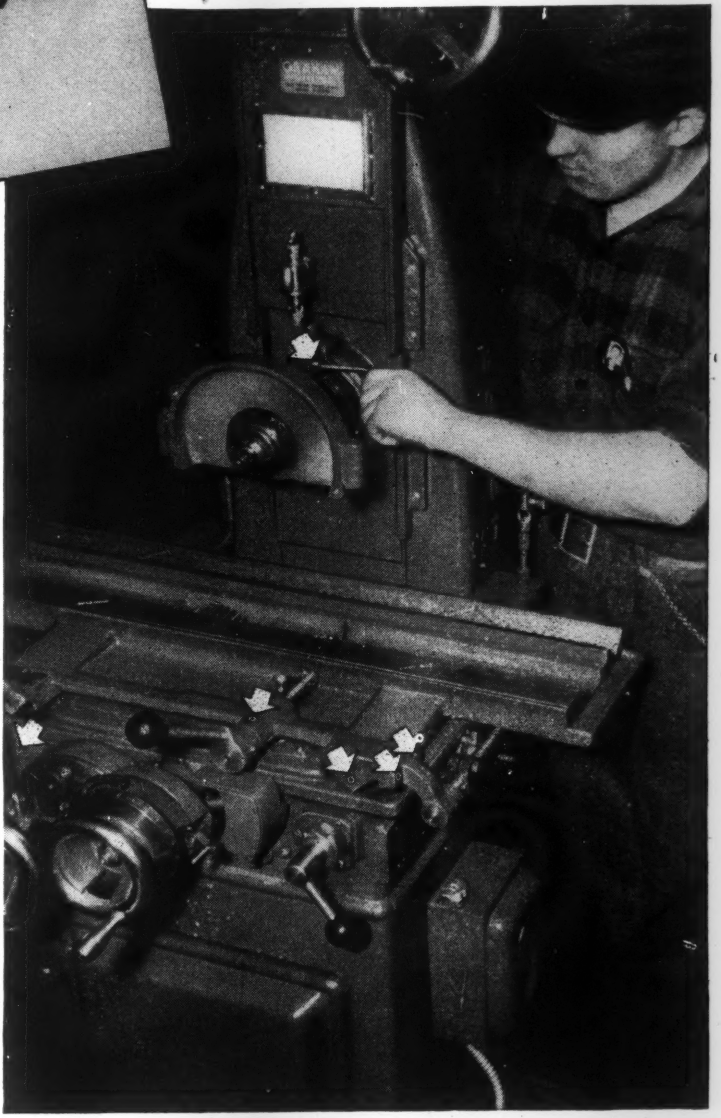
IN PREPARATION for the wide use of new steels in aircraft, it was desired to investigate the hardenability of the steels which were already known to be satisfactory. The end-quench test seemed to be the most suitable tool for doing this.

As the results of the tests were recorded it became apparent that a simple tabulation of values was unnecessarily elaborate and difficult to handle. Therefore a plot of the values was resorted to. On this the hardness is plotted against the distance from the quenched end at which it occurs, as shown in the illustration. Equally divided scales are used with such divisions that it is difficult to read the curve to less than 1 point rockwell C or 1/16-inch. These divisions were selected because the reproducibility from specimen to specimen of the hardness values when the hardness changes slowly is about 1 point rockwell C. The distance division was selected because the size of the hardness indentation when the rockwell type of instrument is used precludes the possibility of more accurately locating the hardness in the rapidly changing portions of the curve.

Two hardenability curves, even when represented on evenly divided coordinates, are difficult to compare when the scales are different. However, by conventionalizing these curves and representing them by a series of numbers

NO PLACE FOR "Doubtful Screws"

. . . in the Machine Tools for Creating War-Vital Precision



Assembling the Robot Surface Grinder requires over 100 Socket Screws – about 60 to hold gears. The Robaczynski Machine Corp. of America, Brooklyn, N. Y., manufacturers of this equipment, get insurance against trouble by specifying "Parker-Kalon".

Machine tools like the Robot Surface Grinders are important "weapons", not only on the production front, but on fighting fronts throughout the world. Repairing and rebuilding mechanized equipment requires shaping and sizing innumerable metal parts to accurate dimensions. For this vital job, performed under the worst possible conditions, only machines of lasting, dependable precision are suitable.

Because it might fail under stress, and delay the return of indispensable fighting equipment to battle, no "doubtful material" can be included in such machines. That is why Parker-Kalon Quality-Controlled Socket Screws are "on the preferred list" of so many machine tool manufacturers.

The unparalleled check-routine supervised by the Parker-Kalon Quality-Control laboratory eliminates "doubtful screws" . . . screws that *look* all right but fail to *work* right. You can be *sure* of the physical and mechanical characteristics of P-K Socket Screws . . . yet they cost no more! Parker-Kalon Corporation, 190-198 Varick Street, New York, N. Y.

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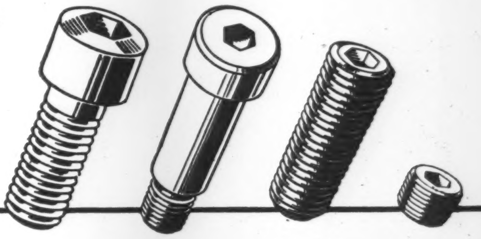

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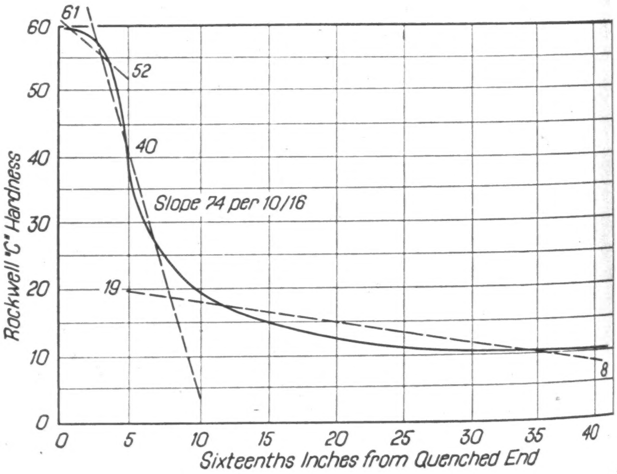
corresponding to characteristics of straight lines which typify the curves, it is possible to compare curves which were initially drawn on very different scales. Further, it is much more convenient to compare large numbers of curves. This is possible because in all cases three or less straight lines can be drawn which will everywhere be within 3 points of the experimental hardenability curve.

Divides Curves into Three Parts

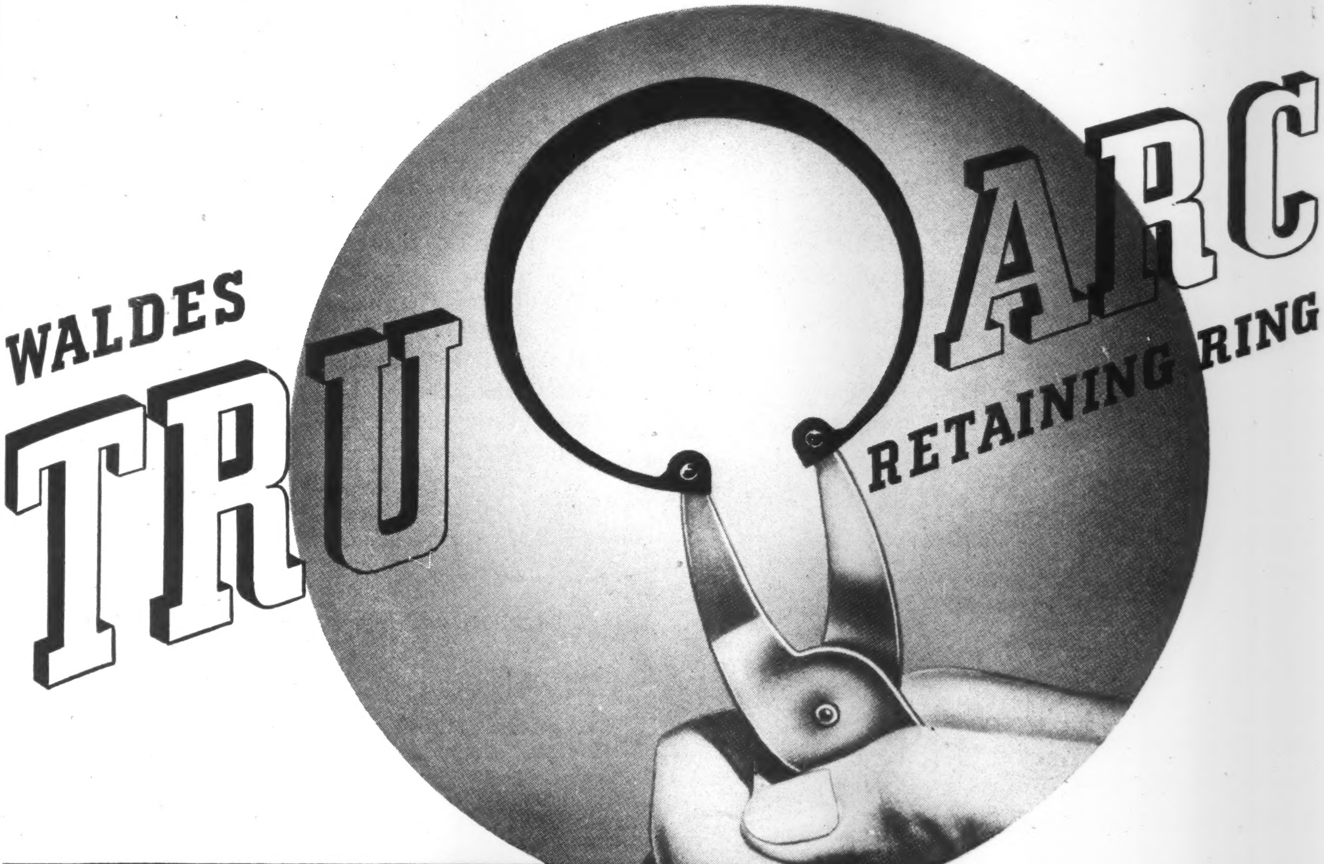
In this representation, the hardenability curve is considered as composed of three parts. Each of these is represented by a straight line, as in the figure. Each of these lines may be described by two numbers, which may be either two points on the line or a point on the line and a function of its slope. Thus the portion of the curve at the high hardness end may be represented by the numbers 61 and 52, which are the zero distance intercept and the intercept at 5/16-inch from the hardened end of the line superimposed on the first portion of the curve. The second portion of the curve, which is more steeply sloped, may be represented by the numbers 40 and 74. Of these, the first is the intersection of the superimposed line at 5/16-inch from the quenched end. The second is the slope of the superimposed line expressed as decrease in hardness for 10/16-inch distance.

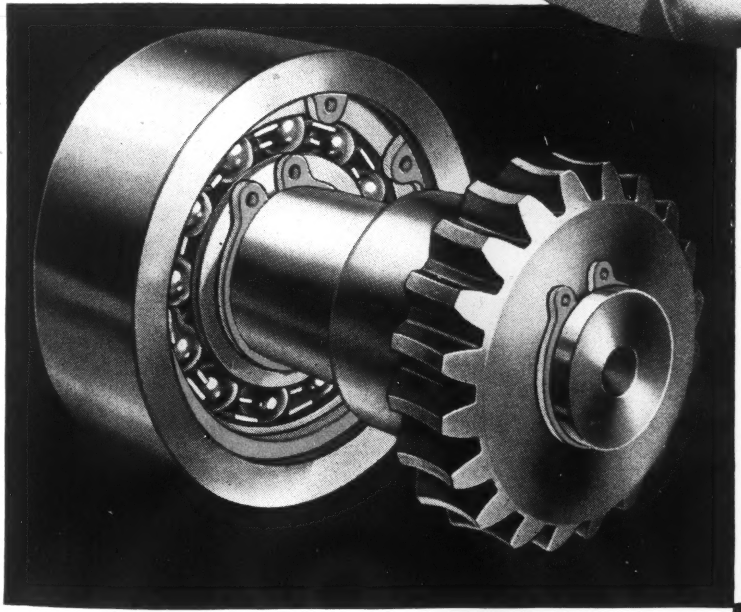
The third portion of the curve may be represented by the numbers 19 and 8, of which the first is the intersection at 5/16-inch from the quenched end and the second is the intersection at 40/16-inch from the quenched end of the superimposed line. For the determination of these lines when the hardenability curve is available, it is sufficiently accurate to rule the lines in by eye with the aid of a transparent straight edge. If care is taken and a sharply pointed pencil is used, the curve will be represented within 3 points rockwell C or 1/16-inch. Generally, over the bulk of the curve the variation will be less than half a point.



With a little practice it is not necessary to redraw the curves, it being possible to interpret the numbers directly. Thus the first pair of numbers indicates the maximum hardness which will be developed. The numbers representing the second portion of the curve show the depth to which the high hardness extends and the rapidity with

WALDES TRU ARC RETAINING RING





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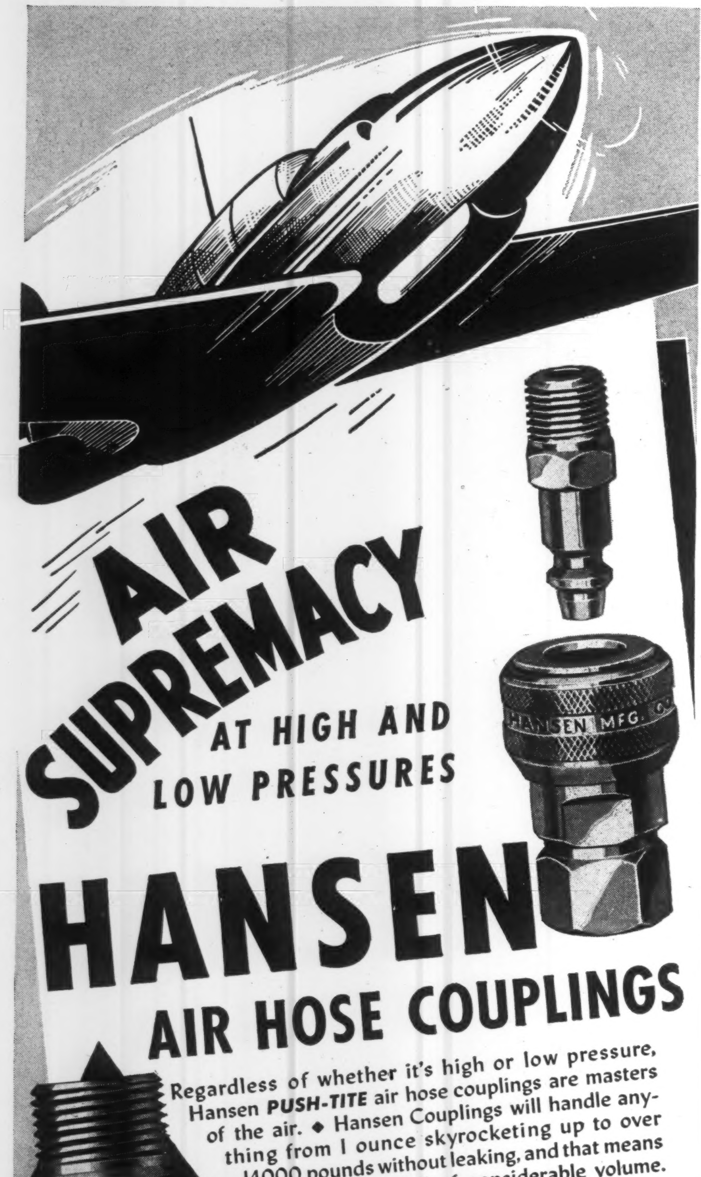

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which the hardness falls off. Thus the amount which the first of the numbers is above the second of the numbers representing the first portion of the curve indicates the extent to which the high hardness extends beyond 5/16-inch from the quenched end. If the first of the numbers is below the second of the numbers of the first portion, then it is the hardness at 5/16-inch from the quenched end. The second number representing the second portion is greater as the rapidity with which the hardness drop is greater. Difference between the numbers representing the third portion of the curve is greater as this portion departs from the horizontal. The second number of the third portion closely represents the lowest hardness obtained. Use of the 5/16-inch distance is arbitrary although selected because most of the steels studied in this investigation harden more deeply than this.—*From a paper by Morse Hill, assistant metallurgist, Materiel Center, Wright field, at the twenty-fourth annual convention of the A.S.M. in Cleveland.*

Standardizing Aviation Powerplants

THE integral powerplant plan means that an aviation powerplant would be built to form the front section of a nacelle—designed, assembled, and tested as a unit by groups specializing on this job. These powerplant specialists would arrange the assembly of engines, turbosuperchargers, generators, propellers, and all accessories, to get a certain performance, one of the items on which overall plane performance depends. Other groups of aerodynamic specialists would, in parallel, prepare the plane up to the nacelle fire wall, and provide the studs or fastenings to which the integral powerplant section would be attached. The fire wall might be a part of the powerplant section, with the various accessories bolted on both sides of it.

It is to be expected that there might be achieved a standardized arrangement, so that any plane would take any integral powerplant of a certain specification. One might even dare to hope for a British-American standard so that an American integral powerplant would fit a British plane, and conversely.

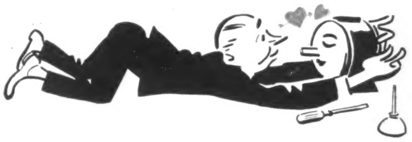
To American engineers and manufacturers, who have brought standardization to such a high pitch, the advantages of this integral powerplant plan seem obvious. No doubt the plan originally was started so as to permit of rapid replacement of powerplants or airplane structures in the field, when damaged in war. We in America have not been up against such problems very long, and so perhaps we have not caught up with the integral powerplant scheme in spite of our boasted skill at mass production. But ease of replacement is a major advantage both in war and peace. Rapidity of production so much needed in wartime is now being helped by manufacture of various components in parallel as independent groups, later assembled to give a complete apparatus. The integral powerplant helps this nicely.

The plan will permit improvements to be made with greater ease. A redesigned powerplant section can be used with an existing plane design or a redesigned plane with an existing powerplant.—*From a paper by Sanford A. Moss, General Electric Co., presented at the recent SAE War Engineering Production meeting in Detroit.*

What do you do when a motor quits?

Well, frankly, you're in a jam.

You should, of course, take care of motors *before* they quit, by giving them the *little* maintenance so necessary to keep them on the job.



For example, let's consider Small Motors . . . those tiny, work-til-they-drop fellows who run your pumps, fans, appliances, and so forth. How long has it been since you gave them a little care?

It's so easy to keep your Small Motors in A-1 shape, happy at their job. Just be on the alert for their common enemies . . . friction, dust, moisture, vibration, overheating, noise.

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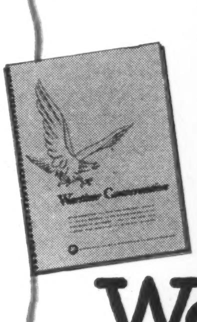
The more we save critical materials and the faster we produce, the sooner these birds will get it in the neck. Here's a book that's a real help. It's the new 100-page Westinghouse "Wartime Conservation" Book. Full of wartime information, it contains recommendations to save critical materials when selecting, applying, or using electrical apparatus. Write (company letterhead, please) for your copy. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., Dept. 7-N.



If your Small Motor is already suffering from "ill-motor health", diagnose the symptoms and get it running again. Probably it's only suffering from a very common ailment.

We have just prepared a new Small Motor Maintenance booklet. It tells you how to protect your motors from their enemies, what to do when they attack. This new booklet is so chock-full of sound information that you will value it from the very moment you receive it.

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Keep those Small Motors on the job—our country needs them! Let us send a free copy of this booklet for each maintenance man in your factory or shop. No obligation. Just tell us how many you need. Ask for B-3215. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N.

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CASE M543

Aircraft windshield wiper application.

Requirements: strength and non-magnetic properties.

Parts of Ampco Metal subject to test—proved satisfactory in both requirements.

Adopted as standard for this application.

STRENGTH plus non-magnetic properties

Parts of AMPCO METAL MET CRITICAL TESTS

The engineers of an aircraft windshield wiper manufacturer needed small bronze parts that had maximum strength and suitable non-magnetic properties—strength to overcome terrific wind stresses; non-magnetic properties to prevent compass variations. Under an 85-hour test, involving 2,000 reciprocating cycles of motor and equipment, parts of Ampco Metal were not worn—proved their superiority in this application.

The selection of Ampco Metal by this manufacturer has been paralleled many times—for engineers in many industries have subjected Ampco bronzes to critical tests and proved the ability of the bronze to safeguard important parts.

Machine tools, aircraft, ordnance,—war production of all kinds where bronzes are used—are equipped with parts of Ampco Metal because they have the necessary toughness and durability to give superior service. With credit to yourself you can use Ampco Metal and solve critical metal problems. "File 41—Engineering Data Sheets" tells how other engineers are using Ampco bronze. Write today for your copy.

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ASSETS to a BOOKCASE

Mechanics of Aircraft Structures

By John E. Younger, professor and chairman of mechanical engineering, University of Maryland; published by the McGraw-Hill Book Co. Inc., New York; 396 pages, 6 by 9 inches, clothbound, available through Machine Design, *$4 postpaid.*

The book is a revised and amplified edition of "Structural Design of Metal Airplanes" by the same author published several years ago and will be of great interest to all designers interested in lightweight structures.

In the first chapter, design elements are considered such as loads to be carried, performance desired, power plants available, safety factor, structural arrangement, aerodynamic considerations, weight and materials.

Other chapters cover the subject in detail, including design of columns and stringers, wing webs, plate structures, fuselage and the like. One entire chapter is devoted to materials and another to riveting.

The book is profusely illustrated and the text is adequately supplemented with tables, formulas and diagrams.

□ □ □

Machine Design

By P. H. Hyland and J. B. Kommers; third edition, published by McGraw-Hill Book Co. Inc., New York; 562 pages, 6 by 9 inches, clothbound; available through Machine Design, *$4.50 postpaid.*

In the revision of this standard text the authors have taken advantage of experience gained in using the book during the five years since the previous edition appeared. Clarity of presentation has been one of the chief aims, in which notable success has been achieved. Rather than allow the book to reach unwieldy proportions, the authors have wisely retained the same size by removing old material where necessary to make room for new.

□ □ □

Substitutes

By H. Bennett, technical director, Glyco Products Co. Inc., published by Chemical Publishing Co. Inc., Brooklyn, N. Y.; 225 pages, 5½ by 8½ inches, clothbound; available through Machine Design, *$4 postpaid.*

Approximately 150 pages of this book are given over to a listing of materials and their substitutes and alternatives and the balance largely to a discussion of substitute requirements. One chapter also is devoted to methods of manufacture, costs, testing, use of finished product and the like.

The book can be regarded in no way as encyclopedic since it does not provide detailed information relative to

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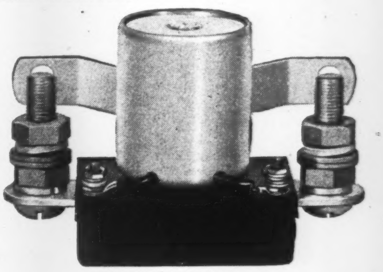

B-8 Solenoid Contactor

"B-8", six pages of Aircraft Contactors—"No. 195", on Midget and Signal Corps Relays

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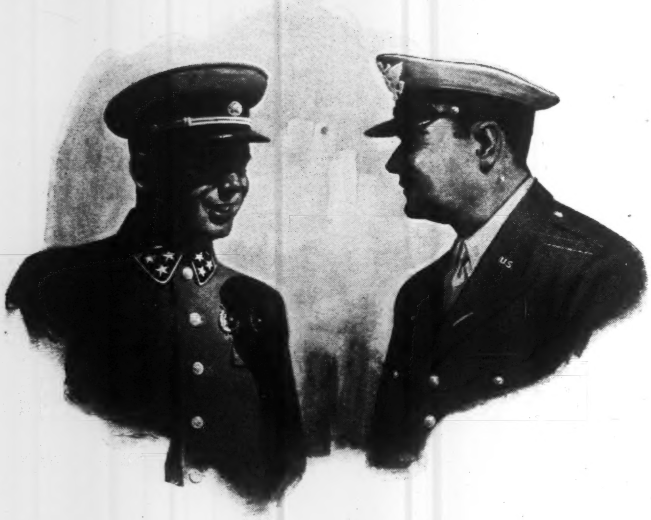

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Don't speak Russian? Then let us translate the words of a Russian General to an American War Correspondent:

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You see, the Correspondent had just remarked upon the number of "Connecticut" field telephones in use by the famed Cossack Cavalry. ↑ ↑ ↑ Like many an American industry, our reputation for know-how rests today on the performance of our products in the service of the United Nations, all around the world. ↑ ↑ ↑ When we can again freely solicit your patronage, there will be no testimonial to which we shall point with greater pride than the commendation of the fighting Russians.

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the individual substitutes proposed. It does, however, give the reader a clue as to the types of substitutes to consider.

For nickel, as an example, the author suggests as substitutes or alternatives: Catalysts, copper-indium alloys, indium alloys, iron-chromium alloys, enameled or coated iron, monel, nitrogen, "Nocorodal" carbon, 96 per cent platinum with 4 per cent tungsten, silver, stainless steel, tin and white copper alloys. Most products are covered beginning with abietic acid and on through zirconium silicate.

□ □ □

High-Speed Diesel Engines

By P. M. Heldt, engineering editor, Automotive Industries; published by P. M. Heldt, Nyack, N. Y.; 430 pages, 5 by 8½ inches, clothbound; available through MACHINE DESIGN, *$4 postpaid.*

The new work by Mr. Heldt represents a revised edition of a book on the same subject published by the author seven years ago. The operating principles of the diesel engine and its injection equipment have not changed in this seven-year period but actual designs of engines and various items of equipment have been revised considerably. A large amount of experience in different fields of application also has accumulated, which will serve as the basis for further development.

In the new edition relatively more space is devoted to American than foreign engines. Seven years ago the American industry was still in its infancy but since has expanded greatly and its products have been refined in many ways. In Europe, diesel engine design was frozen before the outbreak of the war and no doubt the industry since has been engaged in turning out standard military types.

In his present survey of the industry the author has added a chapter on lubrication and another on supercharging, a practice receiving increasing attention. Little progress has been made in development of aircraft types of engines and the chapter on this subject has been shortened.

□ □ □

Chemistry of Engineering Materials

By Robert B. Leighou, late professor of chemistry, Carnegie Institute of Technology; published by the McGraw-Hill Book Co. Inc., New York; 629 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$4.50 postpaid.*

Seven members of the faculty of Carnegie Institute of Technology have completely rewritten, as a fourth edition, a book which has been both useful and familiar to design engineers for many years. New as well as old materials are described in a manner permitting intelligent selection and use. Where process of manufacture has a bearing on properties of materials, the process is outlined.

Several chapters are devoted to iron and steel, the nonferrous metals, and their alloys. The discussion includes

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TONIGHT

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Out of the pioneer meetings came our early progress; out of today's Planning Committees in many organizations and industries will come security and prosperity for a new America.

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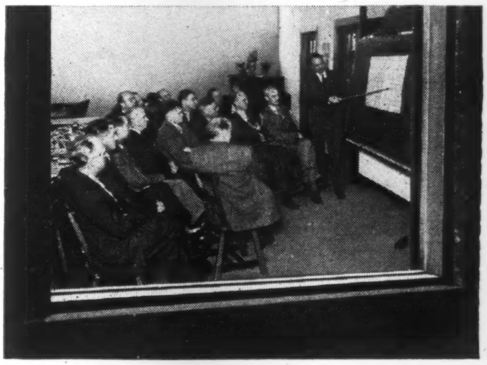

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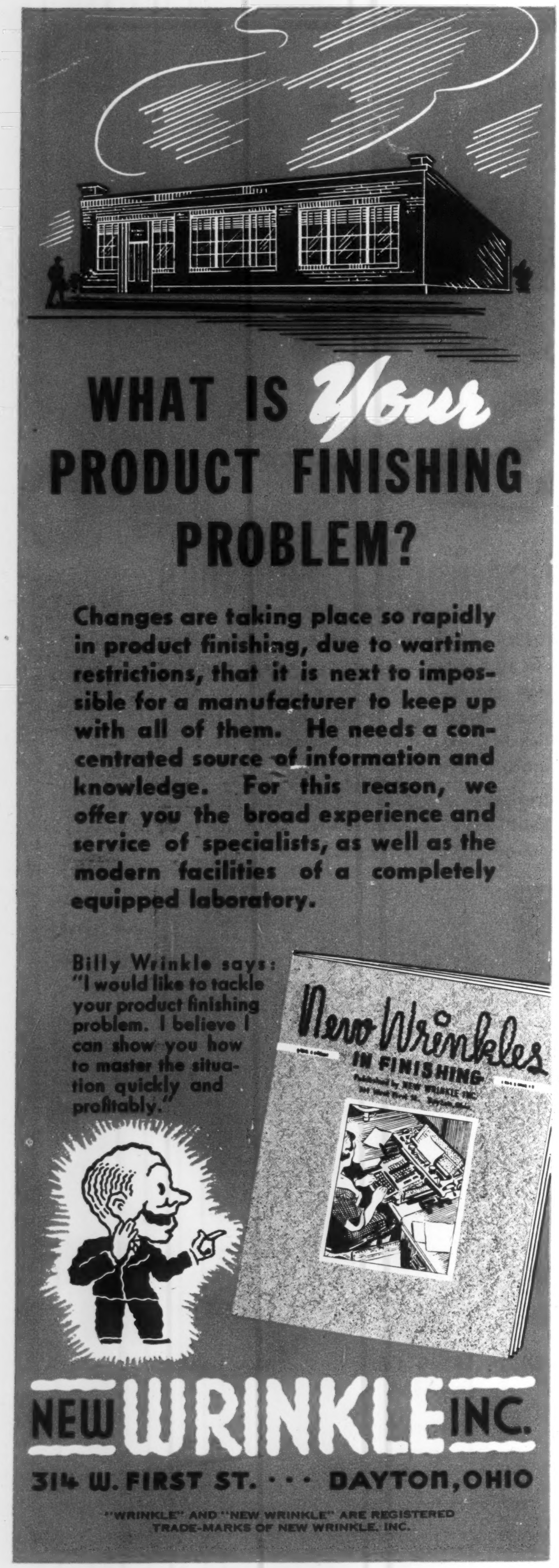
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production processes, types available, corrosion problems, hot and cold working, casting, protective coatings and the like.

Other chapters cover plastics, glass, rubber, abrasives, adhesives, stone and clay products, fuels, lubricants, insulating materials and water for steam generation. The book should serve as a useful reference for practicing engineers, besides being suitable as a text for engineering students.

□ □ □

Engineering Drawing

By Leon Marr Sahag, professor of machine design and drawing, Alabama Polytechnic Institute; published by Ronald Press Co., New York; 394 pages, 6½ by 10 inches, clothbound; available through MACHINE DESIGN, *$2.75 postpaid.*

The author has prepared a textbook based on industrial and teaching experience extending over a period of years and designed to offer the maximum of training in mechanical drawing in a minimum of time.

The book is divided into three parts, elementary, intermediate and advanced, with a logical sequence of chapters in each part. The first part covers all preliminary information required by the student, including lettering, use of the drawing outfit, geometrical drawing, etc. The second part gives him an insight into various types of drawing such as fastenings, piping, structural steel, as well as manufacturing methods and materials of construction. Elementary machine design, jigs and fixtures and the like are covered in the third part.

The text is supplemented extremely well with many illustrations and tables.

□ □ □

Powder Metallurgy

Edited by John Wulff; published by The American Society for Metals, Cleveland; 622 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$7.50 postpaid.*

Current developments of impressive proportions in powder metallurgy have increased the demand for information on this method of producing accurate parts in quantity; therefore the appearance of this volume is especially welcome. The fifty one chapters consist of papers which were presented at the 1940 and 1941 conferences on powder metallurgy, held at the Massachusetts Institute of Technology, and embrace all aspects of the subject. Of particular interest to designers using or contemplating the use of powder metal parts in machines will be the coverage of the properties and uses of various powdered materials. Other topics of interest include hot forging for increased strength, molding of metal powders, machinery for compressing powdered metals, oil-pump gears of powder iron, etc. The book begins with a glossary of powder metallurgy and introductory discussions of early and recent developments, concluding with a patent survey.

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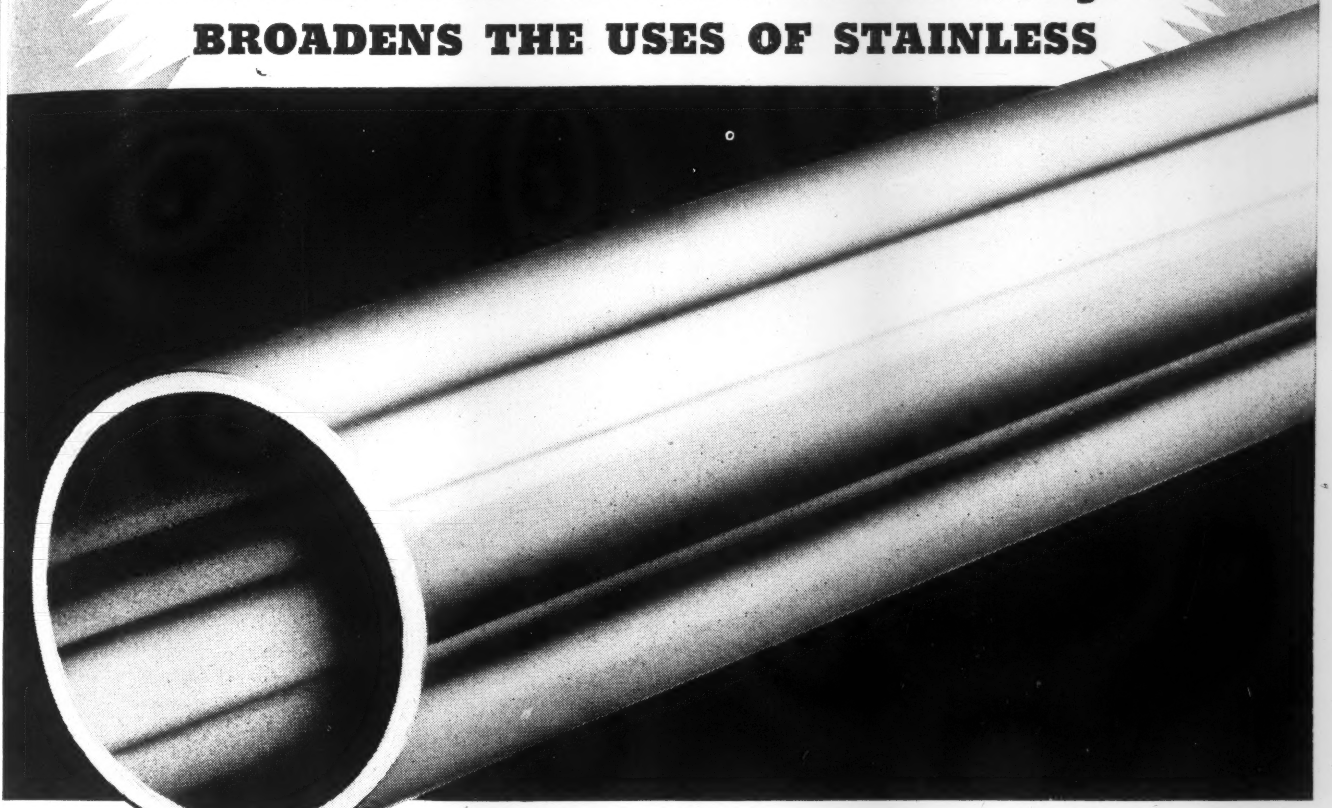

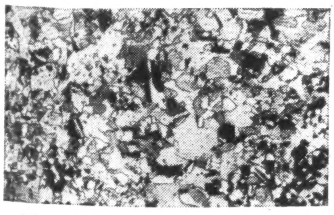

Photomicrograph of weld zone, showing grain structure of weld and parent metal.

THE comparatively lower cost of GLOWELD Stainless Steel Tubing and the wide range of diameter and wall thicknesses, suggest many new applications for stainless tubing. Accuracy to size and gauge permits faster fabrication, easier bending, cutting, welding, expanding and flanging. There is no detectable flash at the weld because GLOWELD is produced by a closely controlled process. Uniformity is achieved through exacting control in production processes and by thorough inspection at every step in manufacture.

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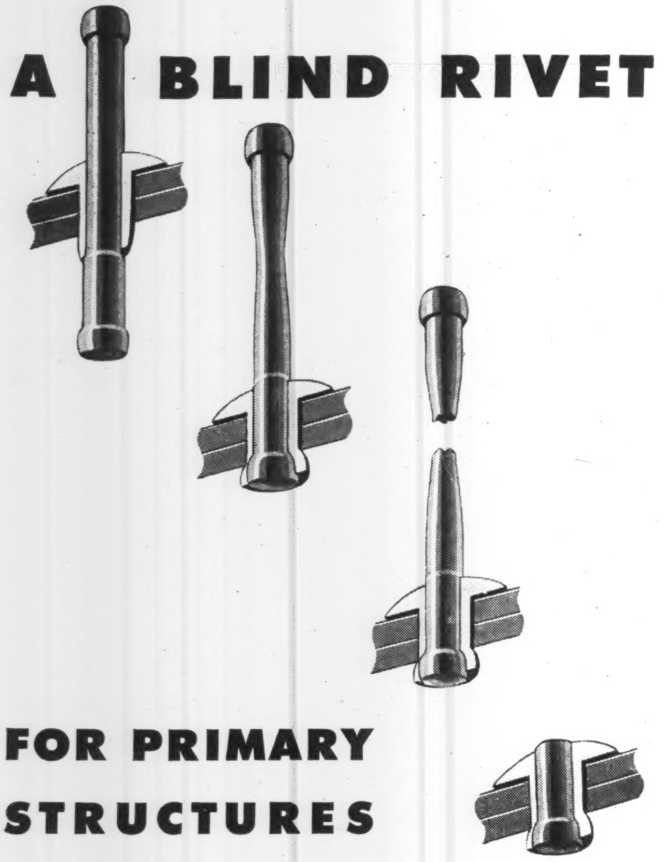
A BLIND RIVET



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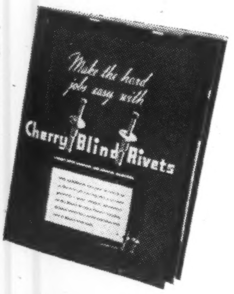

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Company
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"A STITCH IN TIME"– Modern Version

(*Continued from Page* 90)

sary to overcome tolerance stackups throughout the frame, arm and faceplate, which would make accurate die positioning virtually impossible. The arm itself carries a bellcrank which actuates the clincher. The clincher, which takes more severe concentrated impact loads than any other part in the machine, is made double-ended for increased service and is readily removable without the aid of tools. This is accomplished by a pin drive. When the bellcrank is rotated forward and upward by movement of the handle on the actuating rod into the position indicated by dotted lines, the clincher moves upward and the pin disengages. The clincher can then be removed and reversed. In operation the clincher is actuated by means of a cam on the clutch end of the driveshaft. This clincher cam is timed with the faceplate cam, their relative motions being shown in *Fig.* 3.

In order that vertical adjustment of the arm for various work thicknesses would not necessitate adjustment of the clincher for each setup, the actuating rod in the arm is divided into three sections, *Fig.* 4. The adjustment section is contained in the base and is ¾-inch larger in diameter than the intermediate and actuating sections. When the arm is raised or lowered the intermediate section slides across the face of the adjustment section. Lateral adjustment necessary for accurate positioning of the dies under the formers is a function of the arm mounting. The method of mounting permits accurate vertical adjustment of the dies over the ¾-inch adjustment range, and when lateral adjusting screws are pulled up snugly, the arm holds itself at 90 degrees from the ways independently of the lock screws. Penetration and clinching forces are taken by the lock screws in tension. Axial adjustment of the arm is accomplished by the taking up and loosening of diagonally opposite lateral adjustment screws. The only machining accuracy necessary is parallel machining of the ways.

The post machine, *Figs.* 5 and 6, while built on the same base, differs appreciably in general clincher mechanism design. In this model the clinching mechanism, *Fig.* 5, is actuated by a series of bellcranks and tierods which carry the cam motion down the column, out through the base, and up the post. To overcome the difficulty of maintaining accurate die position on a long slender

TABLE I

Properties of Stitched Fastening

Number of Stitches	Ave. Prop. Limit Per Stitch (*pounds*)	Ave. Deformation At Prop. Limit (*inches*)	Ave. Ult. Strength Per Stitch (*pounds*)
Stitch Parallel to Applied Load			
1	154	.0046	479
2	219	.0072	493
3	164	.0048	483
4	180	.0066	469
Stitch at Right Angles to Applied Load			
1	216	.0080	545
2	178	.0059	554
3	163	.0055	563
4	194	.0076	569

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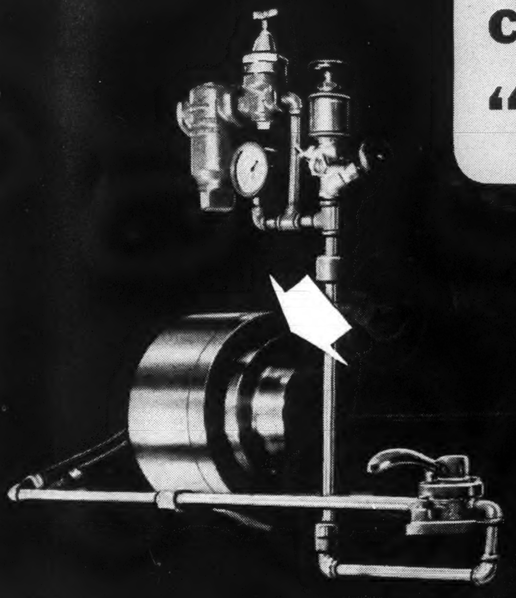

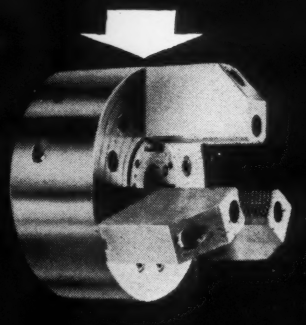

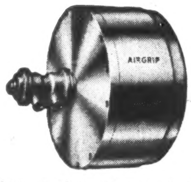

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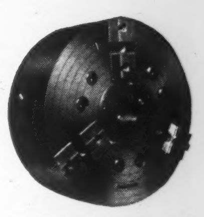

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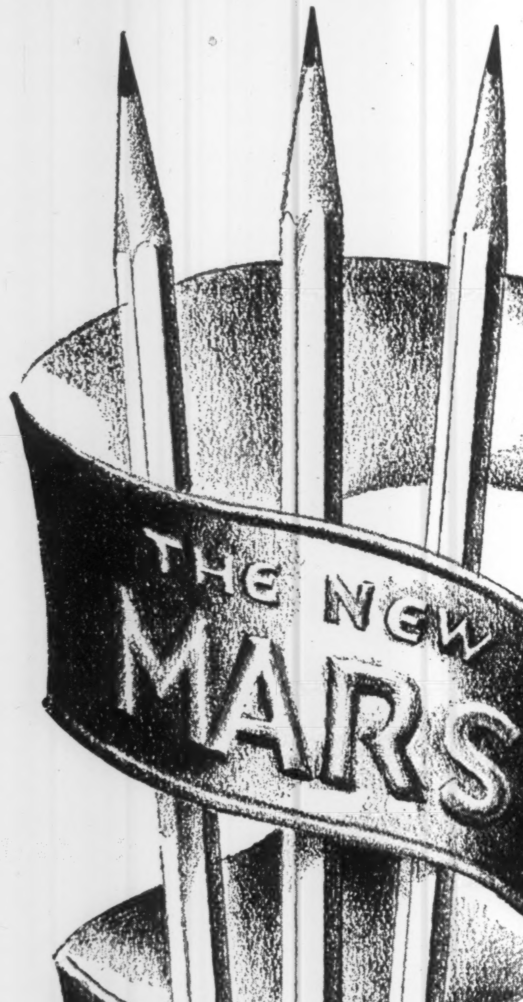

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post, the post mounting bracket, *Fig.* 6, was designed in a manner that applied clinching and penetration loads at a position substantially equidistant from the two widely spaced pivot bearings and an adjusting screw contact point. The two pivot bearings were necessary to permit forward movement of the post head in order to load certain assemblies and to facilitate clincher removal. Since the post axis is between the bearing center line and the jackscrew contact point, fore and aft movement of the post is made impossible when the formers are in the down position clamping the work to the post head. Fore and aft adjustment of the dies is effected by means of the jackscrew contact point, and lateral adjustment by means of screw and ball centers on the stationary pivot shaft.

Design of the post head, *Fig.* 5, was also complicated by space limitations, the necessity for accessible clincher adjustments and the required rigidity. The head itself is machined from round stock and slides snugly into an internally ground section of seamless tube. Clincher is removed by rotating latch and disengaging return plate.

The machines present a minimum of maintenance problems. Parts which need replacing after limited service require either no tools or simply a socket-head wrench for removal. The entire head may be taken off periodically for cleaning by the removal of four cap screws. Clutch and brake parts are equally accessible. All wiring, including electrical trip and nonrepeat device, comes to a central control panel concealed in the frame and serviceable by removing a cover plate.

Pattern Purposely Distorted

Casting of the frame introduced an interesting problem. The casting was designed to be gated on the inner or tension surface of the frame. The section was developed with proper consideration of flow of metal into the mold and of progressive change from thin to heavy sections. Contrary to foundry experience and design expectations, the castings were found to be closing, that is to say, the neck and base of the frame were coming together rather than spreading apart as might normally be expected. After changing the gating and risers to no avail and after having had three castings leave the mold identically, the pattern was distorted to compensate for the error. Identical castings are now obtained from the modified pattern, the casting being given a 25-hour cooling period in the mold.

Cast iron was used for structural members with but one exception. The angle head machine, *Fig.* 1, rear, required a long slender arm for the fabrication of duct assemblies. Although the welded steel construction was found to be more costly than the cast iron in this case, its use was dictated by its higher modulus and the resulting reduction of section necessary to bear stitching loads within allowable deflection limits.

Design focused on quick job changeover, simple adjustments, readily removable perishable parts and maintenance accessibility. Appearance design was considered to be of secondary importance. While the machine presents a clean appearance, its outline and sections are primarily functional. No attempt was made to shroud the motor and drive or to place it within the frame casting. Both would have necessitated the use of sheet steel or excessive cast iron, not felt to be justified at this time. A new finish, "Stipple Batter", was used on the unfilled

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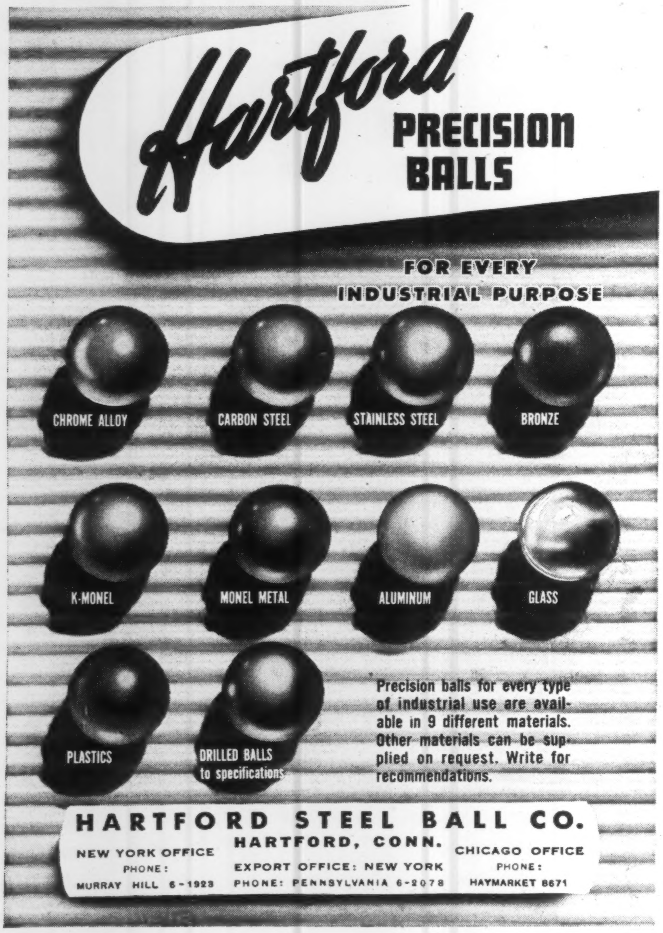

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casting with excellent results. The numerous highlights in this pebbly finish break up the large areas and give a "cleanlined" appearance to the machine. The finish meets Government regulations.

Structural aspects of this method of fastening will be of interest to the engineer and designer. *Fig.* 1 (insert) shows cross section of the stitch in nine sheets of aluminum alloy. The wire used is .0475-inch diameter high-carbon steel, 290,000 pounds per square inch tensile strength, with a hot-dipped zinc coat. While the wire is obviously a push fit in the hole it is interesting to note the cold flow of aluminum in the top sheet and the consequent dimpling of the lower sheets. This produces a mechanical interlock in the joint which is obtained without an additional machine operation. Intermediate sheets have a clean round hole in the bottom of the funnel formed by the passage of the wire.

The zinc-coated carbon steel wire used in aluminum alloy has successfully passed 300-hour salt spray tests. Anodic protection of the zinc coating is sufficient to delay oxidation of the cut wire ends until the plating on the legs has entirely disappeared.

Table I shows typical static load data for stitches in two sheets of 24ST, each .04-inch thick. The wire used was 290,000 pound tensile, .0475-inch diameter carbon steel, zinc-coated.

Variation in proportional limit is attributed to spottiness of 24ST. Since proportional limit is a function of bearing area, and the stitch presents a relatively small projected area, variation is to be expected. In all static tests conducted, the 24ST failed first under load and then the stitch. This is borne out by the uniformity of the ultimate strength values. It is interesting to note that average proportional limit remains practically the same regardless of stitch direction in respect to applied load while ultimate strength of the stitch placed at 90 degrees to the load shows an approximate 25 per cent increase.

In the reception given to this process the natural hesitance of design engineers to accept a new method has been surprisingly absent. New ships, now on the boards, will contain many stitched assemblies. Present designs now in production are changing over rapidly to this method of fabrication.

Substitution Challenges Skill of Designer

(*Continued from Page* 95)

steel tubing was reduced.

In several instances brass rod material has been satisfactorily replaced by plastics. *Fig. 6a,* illustrates adjustable stop screws that are locked in position of adjustment by a set screw compressing a pin. These small pins are used as friction shoes and it has been found that the plastic adopted has frictional properties superior to those of brass at the same pressures. The same plastic substitution has been adopted with equal success to hold retaining nuts in adjusted position.

To conserve brass, thin plastic washers have been adopted as a substitute in parts such as *Fig. 6b*. It has been found that the plastic washers are equally satisfactory for this application. Furthermore, they outlast

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CMP STRIP STEEL
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GIVES MAXIMUM PRODUCTION PER TON

and outwear brass—so a better product is obtained.

Difficulty in obtaining forgings for cranks, *Fig.* 7, prompted the search for a substitute. In this case the fabrication of cranks from three component parts was adopted. The handle portion is a standard item that had already been manufactured as a screw machine product and used in other places, such as on handwheels; the hub portion was newly made from bar stock and the connecting shank portion was manufactured from flat stock. The three parts were then welded together. Under test the cranks adequately withstood severe use, and under sledge-hammer test were considerably abused before failure resulted.

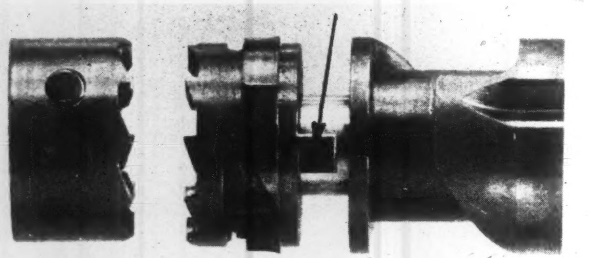

Fig. 8—Substitution of an alternate steel for clutch member required redesign of lug shown by arrow in order to secure adequate impact resistance

Welding has replaced soldering in the manufacture of sheet metal guards, resulting in a considerable saving of tin. It has been found that by simple or minor changes in design, and making allowance for proper overlapping or joining of the parts involved, the substitution is both practical and economical.

For innumerable machine elements such as gears, clutches, ratchets, levers, shafts, spindles, etc., changes have been made to take advantage of the National Emergency steels. In many instances no change has been made in the design of the part, only changes in heat treatment being necessary. In other instances, slight changes in design have been found advisable. For example, *Fig.* 8 shows a clutch assembly in which the central member has a lug or projection, shown by arrow. Although this design proved satisfactory in the steel originally used, when that steel was no longer available extensive tests were conducted on substitute materials. Standard impact specimens were prepared of alternate steels all made alike, hardened at the recommended temperatures and drawn at various temperatures. It was found that none was satisfactory when made to the original design. As a consequence, the design was changed to provide a fillet of larger radius at the base of the lug. To make the new design interchangeable with the old, the radius extends below the face of the member, forming a recess. This provides a better section with sufficient strength and impact resistance, resulting in acceptance of the substitute steel.

The foregoing substitutions and many others were made only after extended tests had been conducted to prove that they entailed no sacrifice in the quality of the part nor any reduction in overall efficiency.

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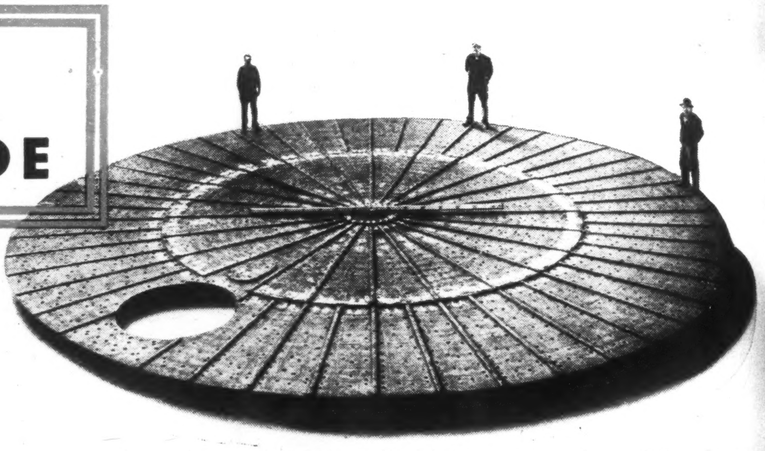

The assembly shown is made up of 90 separate castings of heat-resistant ABSCO Meehanite and each casting is so perfect that it fits into its proper place without the need of machining. What this distributor plate will be used for is a military secret, but suffice to say it will be installed in the largest vessel for pressure operation yet designed and is to be used in the production of two most vital war needs. ABSCO Meehanite Castings were chosen for this 41-ft., 65 ton assembly because of its heat resistance and other favorable characteristics.

There are 21 different types of ABSCO Meehanite, all of which provide high strength, vibration absorption qualities and best machinability. Certain types of ABSCO Meehanite respond to heat treatment and flame hardening, thus providing still higher strength and hardness when needed.

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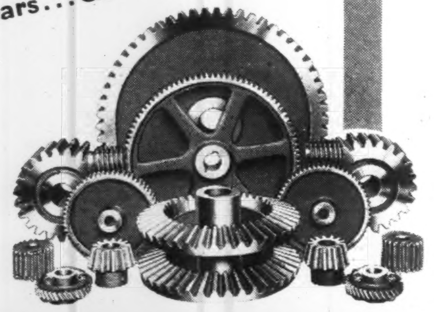

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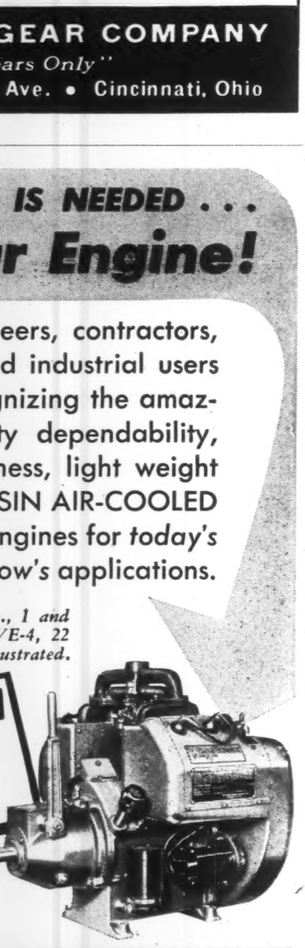

Worried About Specifications? Here's Washington Answer

(Continued from Page 106*)*

acute as it is in this one. About 90 per cent of our normal source of supply of tin and rubber, for instance, is in enemy hands. Every metal normally used in industry, except lead, is currently in insufficient supply. As a consequence, even the armed forces have had to resort to the use of substitutes so that their production may be maintained.

In making any substitution one point should be borne in mind clearly. Authority for the substitution lies only with the design engineers of the contracting Federal agencies—a manufacturer cannot make these substitutions on his own. However, the manufacturer has access to information which can be of assistance as a guide to substitutions that might be made and which he can suggest to the contracting officer. For example, there are the Substitution Guide and the Down-Grading Chart for Brass and Bronze Castings, both published by the Conservation Division.

The Substitution Guide is published from time to time and indicates the general availability of all materials. In this list the materials are divided into three groups:

Guides Published Periodically

Group I lists materials essential to the war program, the supplies of which are insufficient for war and essential civilian demands, and in a number of cases insufficient for war demands alone. Metals in this group are listed in Table I. Secondary and scrap metal, unless otherwise shown, is classified with the corresponding primary metal; in the case of any metal the higher grades are more critical and the secondary grades less critical. Iron and carbon steel, because of relatively greater tonnage, are recommended as substitutes for nonferrous metals.

Group II lists materials essential to the war program, the supplies of which are at present in approximate balance with war and essential civilian demands. Metals in this group are listed in Table II. When considering the use of a material in Group II as a substitute for material in Group I the relative available quantity should be kept in mind, since general substitution of a small tonnage material for a large tonnage material, as for example, silver for copper, would soon exhaust the supply of the smaller tonnage material.

Group III lists noncritical materials, the supplies of which are ample enough to make them available as substitutes for critical materials, unless such supplies are restricted locally by labor, manufacturing, or transportation difficulties. Metals in this group are listed in Table III. American resourcefulness in utilizing the noncritical Group III materials as substitutes for materials in Group I and II will continue to play an important part in winning the war.

The second item is the Down-Grading Chart published herewith. While the ultimate substitution for copper-base alloy castings is of course a ferrous casting,

Cheating the hell box for Victory

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TIMKEN BEARING
EQUIPPED

Warner & Swasey No. 4 Universal Turret Lathe equipped with Timken Bearings machining a part of an aileron control rod end assembly.

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High as performance standards now are in machines of all kinds, they will have to be much higher to assure post-war profits. One way to raise them is use more Timken Bearings. Don't put it off; redesign now.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS
"ALL THERE IS IN BEARINGS"

there are many instances where appreciable conservation can be achieved merely by a specification change within the copper-base alloy field. Such changes in specifications are the responsibility of design engineers. The Down-Grading Chart for Brass and Bronze Castings, Page 105, is intended to serve as a guide in making such changes. Where compositions are shown by four percentage figures, as in the case of composition "G" 88-10-0-2, this means 80 per cent copper, 10 per cent tin, 0 per cent lead, 2 per cent zinc.

Change of Thinking Necessary

Designers under peacetime conditions gave little thought to conservation and specified the best material for the purpose intended. Composition "G" (gunmetal), for instance, has many important and traditional uses. When the supply of raw materials was unrestricted there could be little criticism of a designer who specified this metal for varied uses. Today, however, the .2 or .3 per cent lead maximum in specifications for this bronze places it in a class requiring primary copper and tin for its manufacture. Now the designer must revise his thinking and specify the least restricted material that will do the work at hand.

The chart shows most of the important specifications grouped in columns under the materials required by an ingot maker or foundryman. Four classifications are given. "All New Metal" includes No. 1 and No. 2 copper as well as electrolytic. "High Purity Secondary" is exemplified by such items as fired cartridge cases currently used to make regular manganese bronze. In any specification where the lead is equal to or greater than the tin, the tin content of bronzes can generally be introduced into the alloy from secondary sources such as sweated or unsweated radiator cores. Lead is generally the contamination of secondary supply that restricts the use of material in tighter specifications.

As indicated on the chart, in many instances Composition "M", or even 85-5-5-5 will give adequate service performance for many items where Composition "G" has previously been specified. The Armed Services are recognizing this and have made many specification changes of this nature which conserve primary metal. The Navy, for instance, last spring issued a directive permitting the use of Composition "M" in place of Composition "G" in pressure castings. The Maritime Commission since has changed propeller shaft sleeves from "G" to "M", following lead of the Navy.

Other possible design changes are shown on the chart, and those which are currently most desirable are indicated by the use of heavier connecting lines. The results of work design engineers have done along the lines indicated have been highly encouraging and the saving in primary copper is already measured in terms of thousands of tons per month. By critical examination of end use, design engineers can still accomplish worthwhile savings by carrying out specification changes as indicated. In many instances the changes in properties are minor and well within the design factor of safety; thus no changes in patterns or foundry practices will be required.

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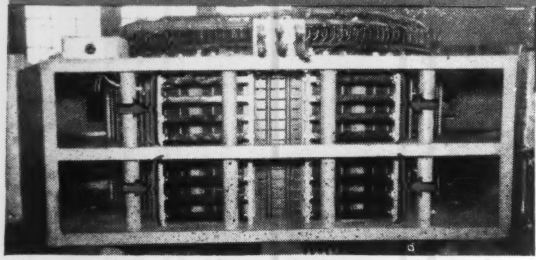
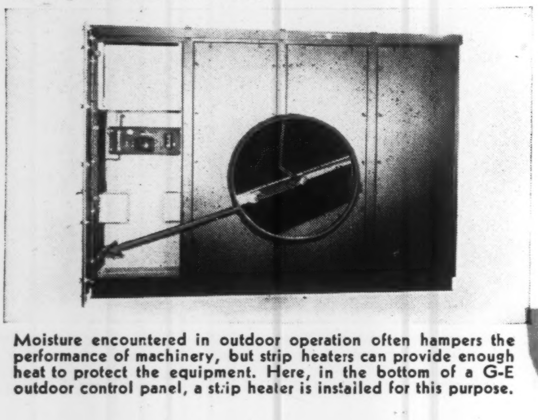


You can prevent moisture from condensing on machinery when it is not in use by installing G-E strip heaters. For this purpose, sixteen strip heaters are installed in the bottom of the stator of this large G-E induction motor.



Moisture encountered in outdoor operation often hampers the performance of machinery, but strip heaters can provide enough heat to protect the equipment. Here, in the bottom of a G-E outdoor control panel, a strip heater is installed for this purpose.

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- keep apparatus free from moisture when not in use
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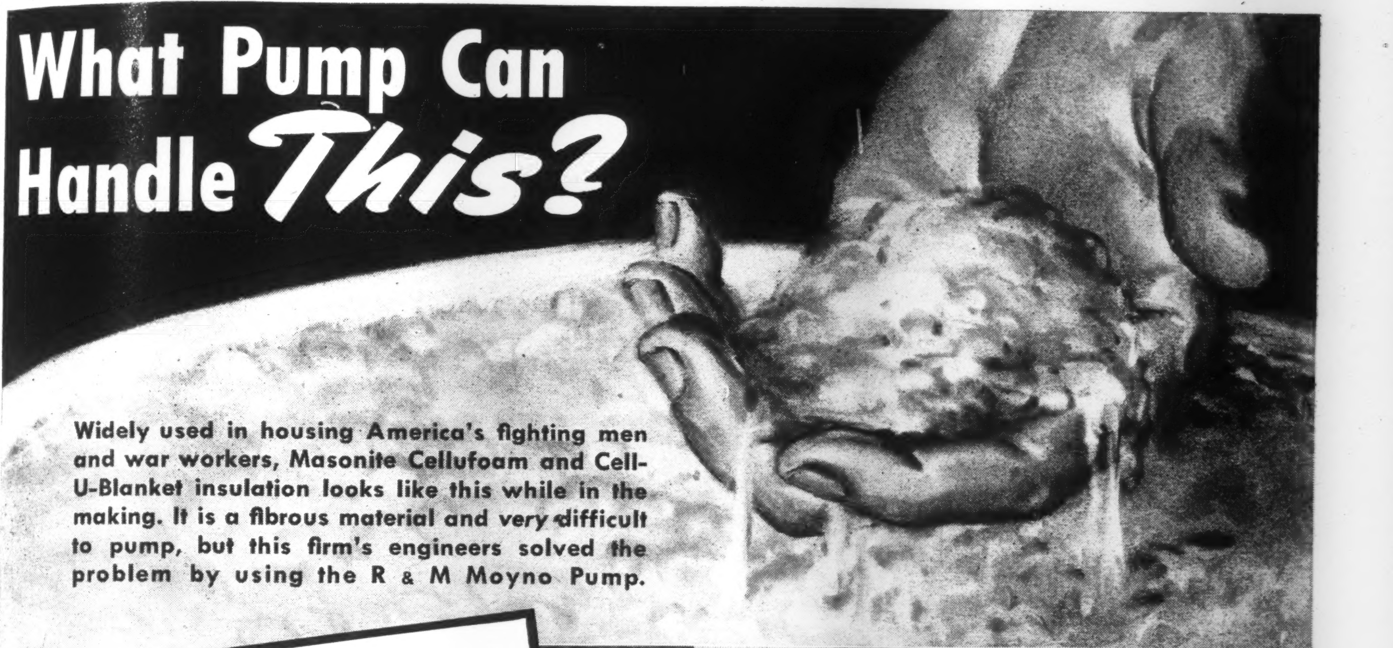
G-E STRIP HEATERS can be used in a hundred ways, either as air heaters or clamp-on contact heaters. You can install them quickly and inexpensively. They can be used either individually or in groups. All sorts of apparatus can be protected from moisture with such installations. Strip heaters also keep delicate equipment operating freely and without stickiness when ambient temperatures are low.

STURDILY CONSTRUCTED, these heaters withstand vibration when installed in machinery. They are available in a large range of sizes and ratings to meet your specific needs.

For prices and detailed information on strip heaters and other G-E midget heaters and devices, write for our catalog, GED-650B. *General Electric, Schenectady, N. Y.*

GENERAL ELECTRIC

What Pump Can Handle *This?*



Widely used in housing America's fighting men and war workers, Masonite Cellufoam and Cell-U-Blanket insulation looks like this while in the making. It is a fibrous material and very difficult to pump, but this firm's engineers solved the problem by using the R & M Moyno Pump.

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"After 3½ years' experience with the R & M Moyno Pump, we are pleased to report that its performance in handling our stock has been very satisfactory.

"It replaced two pumps costing ten times as much, and is doing a far better job. Maintenance costs have been phenomenally low—and the Moyno is so simple in design that when repairs eventually become necessary, it can be taken down and reassembled in about 30 minutes.

"Because of our success with it, we think of the Moyno first whenever other tough pumping jobs come up, and consequently installed a second one recently to pump a supplementary material."

Before installing the R & M Moyno, engineers of the Cellufoam Products Division of the Masonite Corporation were using *two* "special" pumps to handle the 3% Kraft stock used in making their Cellufoam and Cell-U-Blanket insulation. The two pumps cost TEN TIMES as much as the Moyno, and were necessary so that one could operate while the other was being repaired.

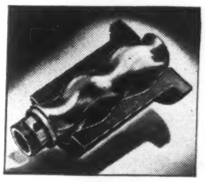
The Moyno, however, not only does this pumping job *better* in every way, but it has cut maintenance costs to an all-time low because of its amazing resistance to wear and its easy accessibility. Also, its smooth, *metered* delivery has helped improve product quality.

In other industries vital to the war effort this pump is solving even *tougher* problems. It's high-pressuring gun-boring coolants, pumping abrasive slip for airplane spark plugs, handling propane gas, glucose, vitreous enamel, heavy acid sludge, and even molten resin. And all with a *record minimum* of wear and maintenance.

If *you* have a pumping problem, investigate the R & M Moyno. Chances are the Moyno can solve it. Write for complete details today!

ONLY 1 MOVING PART!

Here's the patented principle of the R & M Moyno Pump's amazing performance. A single-threaded helical rotor revolves within a double-threaded helical stator, providing pumping action like that of a piston moving through a cylinder of infinite length.



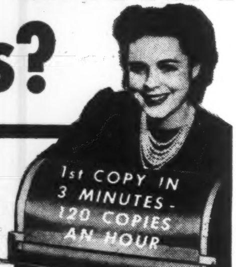
ROBBINS & MYERS • Inc.

MOYNO PUMP DIVISION **SPRINGFIELD, OHIO**

In Canada: Robbins & Myers Co. of Canada, Ltd., Brantford, Ont.

HOISTS • CRANES • MOTORS • MACHINE DRIVES • FANS • FOUNDED 1878

need EXTRA hands?



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AMERICAN PHOTOCOPY EQUIPMENT COMPANY
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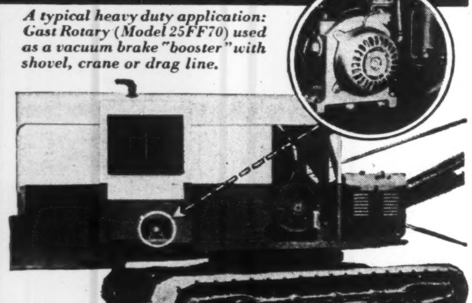
Get GAST Recommendations for Your SPECIAL PUMPS
VACUUM AND PRESSURE

TYPICAL APPLICATIONS . . . . of Gast Engineered-to-the-job Pumps

VACUUM
Refining lubricating oils • Operating automatic chucks on machine tools • Testing instruments • Operating milking machines • Paper feeding, printing-presses.

PRESSURE
Industrial oil burners • Spraying paint or chemicals • Atomization of liquids • Generating cooking gas from liquid fuels—and many hundreds more.

GAST ROTARY AIR PUMPS



A typical heavy duty application: Gast Rotary (Model 25FF70) used as a vacuum brake "booster" with shovel, crane or drag line.

BENEFIT BY GAST ENGINEERING EXPERIENCE

● Manufacturers who bring their pump problems to us find Gast engineered-to-the-job pumps step up performance, reduce operating troubles and increase output. The unique Gast Rotary design provides a more efficient, lower cost operating unit, specially designed for your machine and embodying these features: 1-Smooth, non-pulsating steady flow of air. 2-Forced-Air-Cooling, supplying greater air volume without complicated water systems. 3-Automatic Take-Up, which compensates for wear. 4-Compact design, saving space and weight.

COMPLETE LINE *includes 12 sizes, Gast Rotary Air Pumps, ½ to 23 C.F.M. Vacuum to 28". Pressures up to 30 lbs.*

Send for catalog containing specifications, engineering data and performance tables

GAST MFG. CORP.
107 Hinkley St.
Benton Harbor, Mich.

BUSINESS AND SALES BRIEFS

PROMOTION of L. G. Bean to vice president in charge of engineering and sales has been announced by the Bristol Co., Waterbury, Conn. Mr. Bean was previously vice president and general sales manager. Formerly field sales manager, Harry E. Beane has been made sales manager and E. L. Stilson has become assistant sales manager.

◆

Formerly associated with the steel and tube division of the Timken Roller Bearing Co. and Lukens Steel Co., Robert K. Kulp has been appointed director of research for the Jessop Steel Co., Washington, Pa.

◆

According to an announcement made by the Ohmite Mfg. Co., Chicago, Roy S. Laird, sales manager, has been named vice president. He will continue his sales activity.

◆

In charge of the Bunting Brass & Bronze Co.'s sales and service operations in Chicago, William T. Streicher is being replaced by Martin R. Howe, who has been representing the company in the New England territory. Mr. Streicher has been assigned to the Michigan and Detroit area.

◆

Connected with the Chain Belt Co. since 1935, William W. Klemme has been made district manager of industrial sales in Dallas, Tex. Mr. Klemme was previously district manager at Buffalo.

◆

Eighteen General Electric industrial electronic specialists have been appointed to help industry with electronic application problems. These specialists will be responsible for all industrial electronic applications in their territories.

◆

Removal of headquarters from Pittsburgh to the Pershing building, New Rochelle, N. Y., has been announced by the Meehanite Metal Corp. and Meehanite Research Institute of America Inc. The new offices will feature enlarged laboratory and research facilities.

◆

Promotion of Frank S. O'Neil from general manager to vice president has been announced by Link-Belt Co., Indianapolis. Mr. O'Neil succeeds James S. Watson who is retiring at the end of the year.

◆

For the past two years assistant manager, Air Reduction Sales Co., Wheeling, W. Va., R. J. Rowen has been named manager of the Wheeling district.

◆

Announcement has been made of the opening of an office at 1206 South Maple avenue, Los Angeles, by Handy & Harman, New York city. Connected for many years with the company's brazing engineering division in New York, H. A. Folgner has been placed in charge of the new office, opened

Photo U. S. Army Signal Corps

CAST ARMOR . . . an important contribution of the Steel Castings Industry to the war effort

THE ARMY'S newest and best tanks are by weight 60% cast steel. Casting the armor for tanks—a new process—substantially reduces the cost compared with former methods.

The properties of Steel Castings that make these better tanks possible, and deliver them in less time, are the same properties that will permit you to build a better, more efficient and more economical product.

For information, consult your own steel foundry, or write to Steel Founders' Society of America, 920 Midland Bldg., Cleveland, Ohio.

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS

A NEW JOHNNY GEAR!

More stalwart than ever is Johnny Gear. American troops move forward — fight valiantly — all over the world. Johnny Gear knows that he is helping them. He fights valiantly on the production line — producing Diefendorf Gears for planes—guns—powerful protectors of our American Way of Life.

DIEFENDORF GEAR CORP., Syracuse, N.Y.

diefendorf ★★★★★ GEARS

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ART BROWN

The Department Store of Art Materials

ARTHUR BROWN & BRO.
67 West 44th St. New York, N. Y.

principally to meet the needs created by the rapid growth in the use of the company's silver brazing alloys.

◆

Naming of C. H. Weaver, as manager of the marine section of the industrial department has been announced by Westinghouse Electric & Mfg. Co. Mr. Weaver succeeds J. R. Fulton who has been appointed assistant manager of the industrial department.

◆

Promotion of Robert H. Morse Jr. to general sales manager has been announced by Fairbanks, Morse & Co. Mr. Morse was previously assistant sales manager.

◆

With offices in New York and Philadelphia, Norman C. Einwechter, heretofore a special representative for Carpenter Steel Co., Reading, Pa., has been appointed assistant to the vice president.

◆

Copperweld Steel Co., Warren, Ohio, announces the appointment of M. A. Williams as district sales manager of a new branch office at the Circle Tower, Indianapolis. Included in his territory will be central and southern Indiana, southwestern Ohio and the state of Kentucky.

◆

Since 1928 associated with Formica Insulating Co., Cincinnati, J. Roger White has been elected vice president in charge of sales for the company.

◆

For the past eight years a subsidiary of the Torrington Co. of Torrington, Conn., the Bantam Bearing Corp., South Bend, Ind., has been merged with its parent company and will be known as the Torrington Co., Bantam Bearings Div. The present personnel will be retained and operations will continue from the South Bend headquarters.

◆

B. F. Goodrich Co., Akron, O., has announced the appointment of Jay E. Miller, sales promotion manager and Harold F. Mosher, manager, special industrial merchandise.

◆

Formerly sales manager of the Cleveland district, C. J. Bickler has been appointed assistant to the vice president in charge of sales of the Globe Steel Tubes Co., with offices at Milwaukee, Wis.

◆

M. B. Sunderland has been named manager of sales in charge of the low-alloy, high-tensile steel products division of the Carnegie-Illinois Steel Corp., with headquarters at the Carnegie building, Pittsburgh.

◆

Leave of absence has been granted Kenneth W. Cole, manager of the Chicago office of the Pressed Steel Tank Co., Milwaukee, as he has accepted an appointment with the War Production Board, Washington, D. C.

◆

For several years a member of the Pittsburgh district sales office of the Allegheny Ludlum Corp., and recently assistant district manager, Robert H. Gibb has been named district manager of that office.

◆

Edward Beard White has been named sales manager in the western territory for Eutectic Welding Alloys Co., New York.

◆

Despite the fact that the Dumore Co., Racine, Wis., was celebrating its thirtieth anniversary, assembly lines where frac-

To help you SOLVE TUBING CONNECTION PROBLEMS

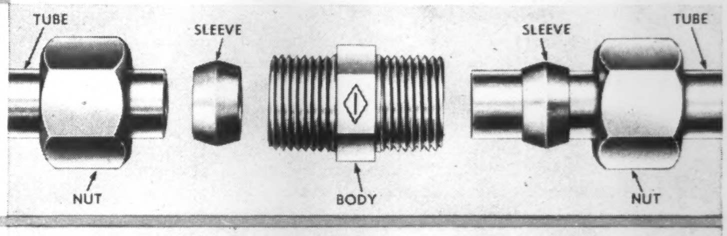
FOR many years the Imperial organization has been working with manufacturers on the problem of selecting the right fittings to best handle specific tubing connection problems. The types of Imperial fittings that are used in connecting up fuel, lubricating oil, water, air, refrigerant, and other lines are illustrated here for ready reference.

If you have problems that involve the use of tubing connections on essential war equipment or on production machines that are turning out war products, we should be pleased to supply you with detailed information on any, or all, of these types of fittings.

THE IMPERIAL BRASS MFG. CO., 513 S. Racine Ave., Chicago, Ill.

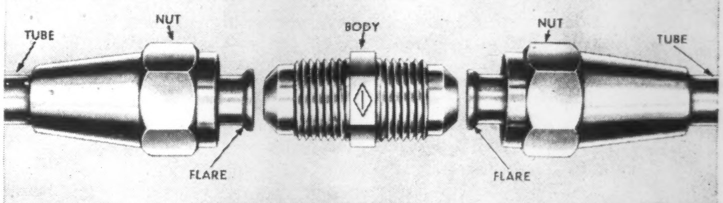
IMPERIAL COMPRESSION FITTING

The Imperial Brass Manufacturing Company originated this compression type fitting which has been widely used in the industrial and automotive fields. No soldering, flaring or threading is necessary The loose sleeve slips over the tubing and is seated by compression when the nut is tightened.



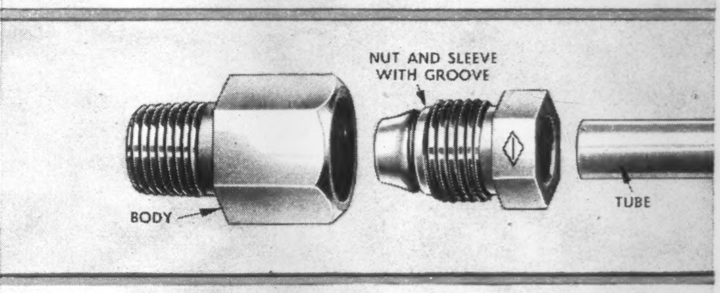
IMPERIAL S.A.E. FLARE FITTING

The Imperial S.A.E. Flared Fitting is especially adapted for high pressure service and has the advantage that it will withstand a severe tensile pull without failure. This fitting is widely used in industrial and automotive applications and in such services as refrigeration.



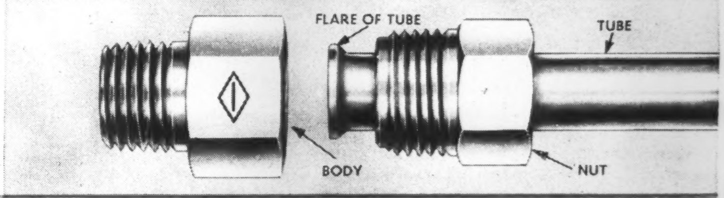
IMPERIAL HI-DUTY FITTING

This fitting is an improvement on the compression design. It consists of a nut with a grooved sleeve and a body When the nut is tightened the sleeve shears off and compresses on the tube and becomes a permanent part of the tube. The correct alignment of the sleeve is also automatically maintained. When assembling there is no loose sleeve to contend with and the Hi-Duty fitting stands up much better under vibration. It can be coupled and recoupled at will and always reconnects tight.



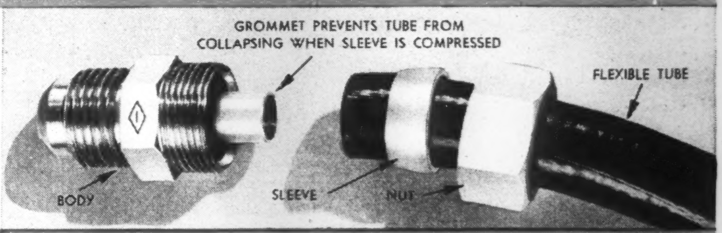
IMPERIAL INVERTED FLARE FITTING

In this fitting the nut screws into the body instead of over the body. This fitting is used in automotive applications excepting in close connection work.



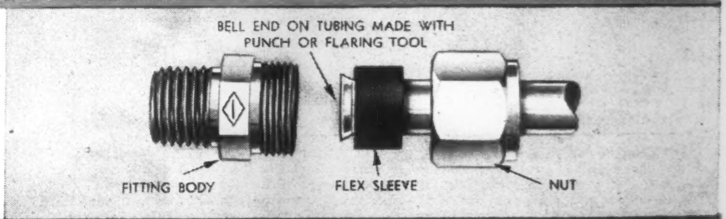
IMPERIAL TYPE "FN" FITTING

This fitting was developed for use with flexible tubing. It is a three piece compression fitting with a built-in grommet to prevent the tube from collapsing This fitting is widely used on war equipment and on trucks, buses, tractors, and similar applications where the use of flexible tubing is required due to extreme vibration and tube movement.


GROMMET PREVENTS TUBE FROM COLLAPSING WHEN SLEEVE IS COMPRESSED
FLEXIBLE TUBE
BODY
SLEEVE
NUT

IMPERIAL FLEX FITTING

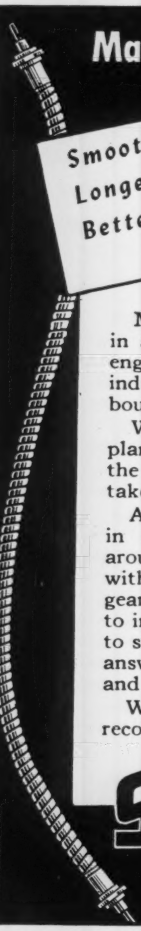
This fitting was developed for applications where extreme vibration is encountered and where the vibration between the different parts to be connected is in different planes and amplitudes, but where only minor tube movement is involved. In this fitting a sleeve made out of synthetic elastic material is used



IMPERIAL

TUBE FITTINGS AND COUPLINGS FOR COPPER, BRASS, STEEL, ALUMINUM AND SYNTHETIC TUBING, SHUT-OFF COCKS, STRAINERS, TUBE CUTTERS, BENDERS AND FLARING TOOLS

Machines are Easier to Make...



Smoother Running
Longer Lasting
Better Styled
with...

STOW
FLEXIBLE SHAFTING

Make no mistake about it, this war *is* ushering in a new order—especially in revolutionary new engineering and manufacturing methods on both industrial and consumer machines. The trend is bound to grow.

With engineers having the "know how" of airplanes, tanks, ships, jeeps and automatic guns, the short, quick way of doing things is going to take precedence.

And that's where Stow Flexible Shafting comes in for consideration. For it transmits torque around bends, through angles and tight spots, without universals and slip-joints . . . often saving gearing, bearings, housings, brackets. It is cheaper to install, lowers manufacturing costs, contributes to streamline styling. It's the designing engineer's answer to many problems of power transmission and control.

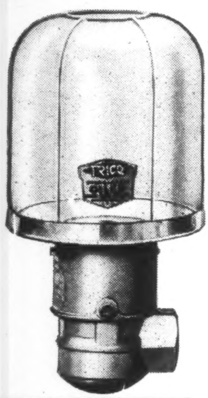
We will gladly furnish, without obligation, our recommendations on any specific design problem.

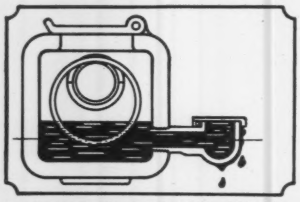
STOW MFG. CO., Inc.
11 Shear St.,
Binghamton, New York

TRICO OILERS

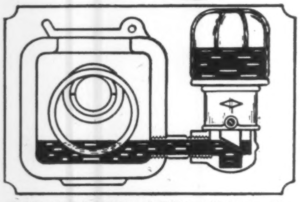
OPTO-MATIC Constant Level Oilers are providing remarkable service and complete satisfaction, with definite economies in operation and maintenance. They modernize your equipment, increase your prestige and reduce selling resistance.

- Oil supply always visible
- Save time, oil, and worry.
- Reduce bearing failures.
- Stop guesswork.
- Avoid needless shutdowns.
- Reduce fire and accident hazards.





THE OLD FASHIONED WAY—With hand-oiling, oil is usually poured into a bearing faster than it can overflow at the oil cup, resulting in waste, flooding of motor windings, messy floors, etc. If oil level becomes too low, bearing failures result. IT'S ALL GUESSWORK.



THE "OPTO-MATIC" WAY—The oil level in the bearing is automatically maintained. As oil is consumed the OPTO-MATIC feeds new oil—instantly and positively—no guesswork—no hazards. Oil supply is always visible. The potential value of any machine is increased.

WRITE FOR BULLETINS

TRICO FUSE MFG. CO., Milwaukee, Wis.
In Canada: IRVING SMITH LIMITED, Montreal

tional horsepower aircraft motors and precision grinding tools are built were kept moving. The event was celebrated by everyone during the noon hour.

◆

Associated for the past 15 years with the D. O. James Mfg. Co., Chicago, R. X. Raymond is now in charge of the Minneapolis offices located at the Fawkes building, 1645 Hennepin avenue.

◆

For the past three years in charge of wholesale and industrial sales through the Lamson & Sessions Co.'s branch offices in Chicago, New York, Birmingham, St. Louis, Salt Lake City, Los Angeles, San Francisco and Seattle, Robert C. Patterson has been appointed general sales manager of the Cleveland office.

◆

According to an announcement released from the Wheelco Instruments Co., Chicago, three additions have been made to the sales and service staff. Formerly in the Tulsa territory, Hugh Acock has been named Texas district manager with headquarters in Houston. C. H. Garrison has been named Kansas City representative, covering the western counties of Missouri. With headquarters in Chicago, Russell George has been added to the sales and service department of the company's combustion safeguard division.

◆

Gilbert L. Dannehower, a mechanical engineer, has been appointed sales manager of the Swiss American Gear Co., Jersey City, N. J. Mr. Dannehower will also manage the sales of the Cosa Corp., Chrysler building, New York.

◆

Following a recent meeting of the Board of Directors, three promotions were announced by SKF Industries Inc., Philadelphia, among which are: Thomas W. Dinlocker elected vice president and treasurer, and Richard H. DeMott, vice president in charge of sales.

◆

A new sales and service representative, Hugh A. Brightwell, has been announced by Manning, Maxwell & Moore Inc. Mr. Brightwell will represent the Bridgeport divisions in the Tulsa, Okla., district.

◆

In addition to being in charge of sales of Van Norman Machine Tool Co., Helge G. Hoglund will have complete control of sales of the new electronics division which is manufacturing induction heating equipment.

◆

Promotion has been announced of George E. Anderson as field engineer to cover the territories of Western Pennsylvania, Western Maryland, West Virginia and Western Virginia for the National Forge & Ordnance Co., Irvine, Warren County, Pa.

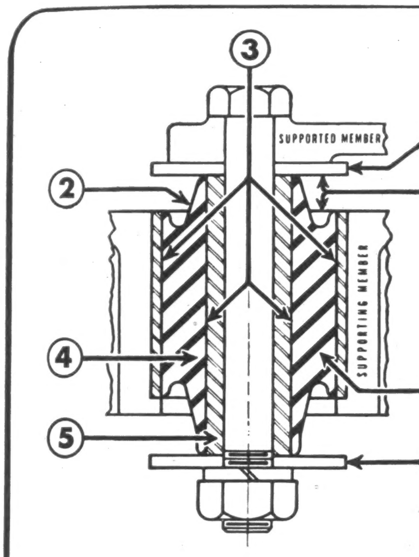
◆

For the past nine years connected with Kieley & Mueller Inc., V. W. Farris has recently organized the Farris Engineering Co. Occupying a new plant at Ridgefield, N. J., the company is manufacturing equipment for the Navy, Maritime Commission and other groups assisting in the war effort.

◆

Previously associated with W. O. Barnes Co. Inc., Detroit, Ellsworth Brash, has been appointed district representative for Pennsylvania and New York state by the Allen Mfg. Co., Hartford, Conn. New York city and Long Island territories will continue to be served by Willis D. Horner.

DESIGNING for use of LORD BONDED RUBBER TUBE FORM MOUNTINGS



3
SUPPORTED MEMBER
7
2
1
SUPPORTING MEMBER
4
6
5
7

EXCLUSIVE FEATURES

❶ **End Extension**—Provides clearance between the metal members for free movement in shear.

❷ **End Shape**—Throws flexing action away from the metal parts into the rubber body, preventing stress concentration at the edge of the bond.

❸ **Rubber-to-Metal Bond**—Lord methods produce a high ratio of bond strength to working stress, resulting in a bond that is as strong or stronger than the rubber, an important factor of safety.

❹ **Rubber Compounds**—Developed particularly for shear type mountings utilized in varying degrees of stiffness to meet specific spring rate requirements.

❺ **Center Sleeve**—Dimensions may be changed to meet any unique mounting condition.

❻ **Sound**—Transference through Solid Conduction is cut off by Lord Mountings. The isolation of sound, a high frequency vibration, is demonstrated by the transmissibility formula.

❼ **Safety**—Stop washers at each end of the mounting form an interlocking system of metal, providing safety and preventing undue movement under shock loads.

LORD Shear Type Bonded Rubber Tube Form Mountings are designed to operate in full shear freedom when loaded in the direction of the main axis of the mountings. This design for free shear softness in the direction of the disturbing forces, results in an exceptional reduction in the frequency of the mounted system.

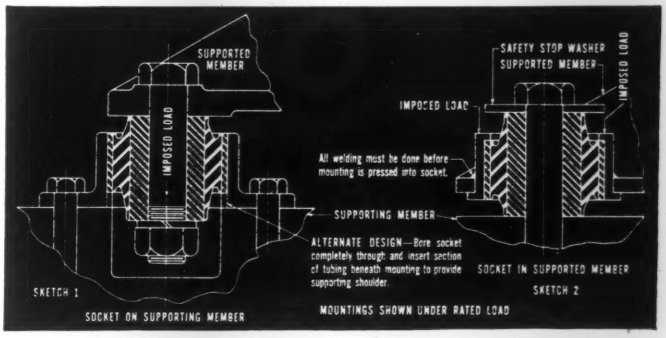
Lord Tube Form Mountings are made in various styles and sizes, with flanged or straight outer metal members, with snubbing or non-snubbing features, and in load capacities ranging from a few pounds to 1500 pounds.

Lord Mountings isolate vibration, absorb shock and minimize all noise translated through solid conduction. They are sturdy, compact, light weight units, and ease of installation is an important feature. No special equipment is necessary to install Lord Mountings. Simply clamp or press them into sockets provided in either the supported or supporting structure.

Sketch No. 1 shows an installation in which the socket is fastened to the supporting member and the load is imposed on the center metal sleeve. The shoulder shown in bore of socket is useful in positioning mountings but not absolutely essential.

Sketch No. 2 illustrates an installation in which the socket is fastened to the supported member and the load is imposed on the outer metal member. In either type of installation a press fit of .001 inch to .012 inch, depending upon mounting diameter, will prevent slippage.

Complete information on all Lord Mountings is contained in our bulletins 103 and 104. Send for your copy or call in a Lord engineer for consultation on your vibration problems. There is no obligation.



SUPPORTED MEMBER
IMPOSED LOAD
SKETCH 1
SOCKET ON SUPPORTING MEMBER
All welding must be done before mounting is pressed into socket.
SUPPORTING MEMBER
ALTERNATE DESIGN—Bore socket completely through and insert section of tubing beneath mounting to provide supporting shoulder.
MOUNTINGS SHOWN UNDER RATED LOAD
SAFETY STOP WASHER
SUPPORTED MEMBER
IMPOSED LOAD
IMPOSED LOAD
SOCKET IN SUPPORTED MEMBER
SKETCH 2

IT TAKES RUBBER *IN SHEAR* TO ABSORB VIBRATION

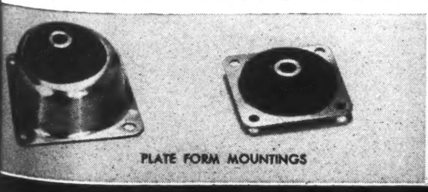
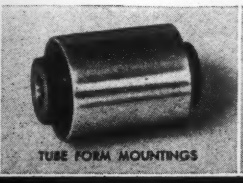
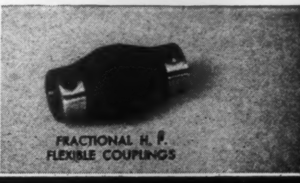


PLATE FORM MOUNTINGS

LORD BONDED RUBBER


TUBE FORM MOUNTINGS


FRACTIONAL H. P. FLEXIBLE COUPLINGS

LORD MANUFACTURING COMPANY . . . ERIE, PENNSYLVANIA

Originators of Shear Type Bonded Rubber Mountings

SALES REPRESENTATIVES · NEW YORK, 280 Madison Ave. · CHICAGO, 520 N. Michigan Ave. · DETROIT, 7310 Woodward Ave. · BURBANK, CAL., 245 E. Olive Ave.